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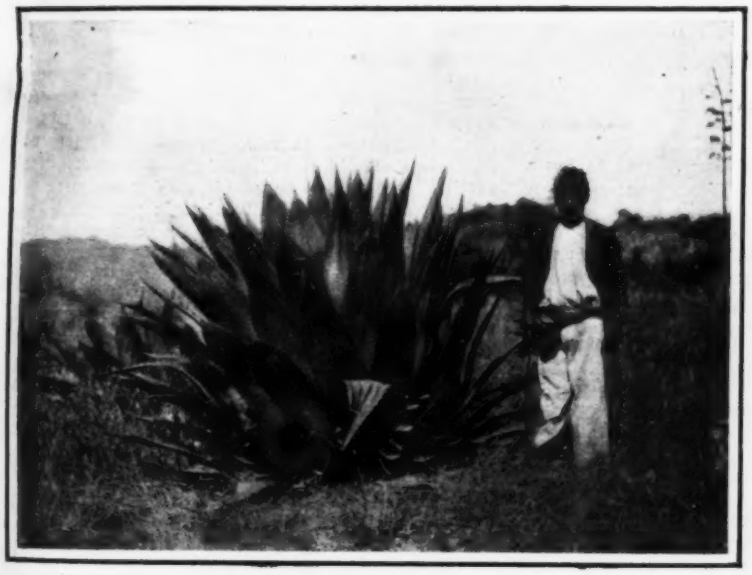
UNNAMED COLINA MAGUAY NO. 1.

UNNAMED COLINA MAGUAY NO. 2



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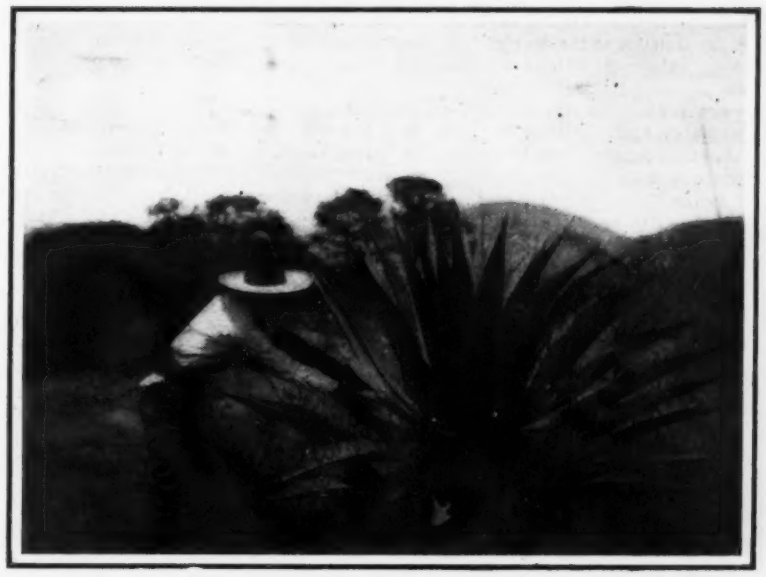

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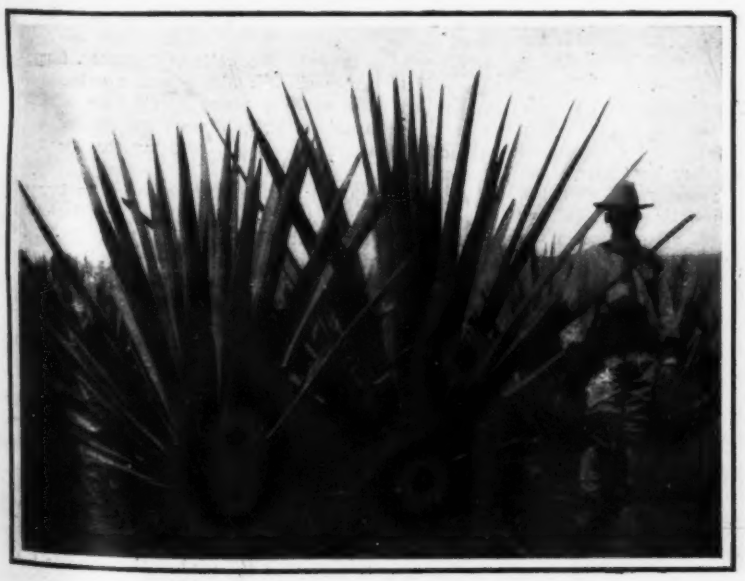


TEQUILA MAGUAY, VARIETY MANO LARGA. NO. 5.

TEQUILA MAGUAY, VARIETY GRANDA. NO. 6.

MAGUAY FIBER.

MAGUAY FIBER.*

A PLANT WITH INDUSTRIAL POSSIBILITIES.

BY CHARLES RICHARDS DODGE.

FROM time to time, during the past two or three years, there have been references to maguay fiber in the public press, and now small quantities are finding a market in this country. As the term *maguay* is used in Mexico in a generic sense, and refers to the species of plants comprising a large group of Agaves rather than to any one definite species, some brief statements upon the subject seem necessary, at this time, to show precisely what is meant by "maguay fiber."

Among the one hundred and fifty, or more, species of the genus *Agave* known to the Mexican flora, there are a number of giant species, of robust habit, with broad heavy leaves, which yield a rather soft, almost white fiber showing certain very marked characteristics. If the fiber of any one species of these maguays should be taken as the type, I would name that of the century plant, *Agave Americana*, not only known as the "maguay," but as the American aloe—a plant that is now perfectly naturalized in all tropic and sub-tropic countries.

The fiber of this species is five to eight feet long, almost white (I have seen it quite white) and is somewhat brilliant; it has a slight waviness, or a crimped appearance, and while not as strong as sisal hemp, it may be considered a fairly strong fiber. It also possesses the characteristic of elasticity to a marked degree, and on this account might be employed to advantage where strength with a quality of springiness is desired. Leaves 8 to 10 feet long and a foot wide are not uncommon, although such bulky leaves are not so economically cleaned as other leaves because they must be split or subdivided, while the leaf of the sisal hemp plant, for example, can be put through the machine entire.

Several species of these giant agaves are cultivated in Mexico for "pulque" (though not for fiber), the vast plantations covering a radius of fifty miles around the city of Mexico. The fiber from all of these species belongs to the *Americana* type, showing the same characteristics as the fiber of the "maguay" or century plant. Blazquez, a Mexican authority and writer upon the subject, has enumerated thirty-three species of maguay agaves which grow or are cultivated on the plains of Apam, sixteen of which yield the beverage known as pulque. And there are many more in other portions of the republic.

In the Colima region of southwest Mexico, the writer found half a dozen or more species of another group of agaves which are also to be classed with the maguays. The plants are smaller than the preceding, but they bear broad, spined leaves which yield a somewhat similar fiber to the *Americana* type, though a little darker in color and less wavy. These species (Nos. 1 and 4) are similar in form, but, as far as I can learn, have not been identified. I had the fiber of several species extracted by hand, and found that the yield was less than two per cent of the weight of the growing leaf. The Colima fiber has already been employed in manufacture, in Mexico, and I understand that a machine for its extraction has been operated for some time at the hacienda La Joya, near the volcano of Colima. The plants are striking in appearance, and as the species cannot be named I will refer to the illustrations by the numbers given them in my notebook. I should state, however, that No. 1 belongs to a different group of agaves, and is not unlike *Agave Americana*. Señor Teresa, who accompanied me on this trip, considered the plant to be a giant century plant, but it was not identified. No. 4, which was found growing at a high altitude on Mount Colima, has rather heavier leaves than the plant bearing the No. 1, but it belongs to this group of maguays. No. 1 bore leaves which averaged ten inches wide, but are not over five-eighths of an inch thick at the center. Leaves from another specimen were eight inches wide, three-eighths of an inch thick in the center, and not half that measurement two inches from the edges. As the plants blossom in six or seven years, which destroys them, the owners of hacienda La Joya were establishing nurseries where the young plants could be cultivated and the supply of fiber-yielding old plants maintained.

Around Tequila, in the State of Jalisco in western Mexico, another group of maguays is found, several species of which have been utilized for fiber, especially *Agave colina*. The hearts of these plants are utilized for the mescal liquor, or Tequila wine, which is distilled from them. Among the local varieties are the *mano larga* (No. 5) *chato*, *azul*, *granda*, etc., but they bear no resemblance in form either to the giant agaves found on the plains of Apam or to those of the Colima group of maguays. In general form and habit of growth the species resemble more nearly the sisal hemp plant as it appears in southern Florida, where it is trunkless. No. 6 is an isolated specimen of the variety known as *granda*. The leaves of this group of maguays are straight and erect, 5 to 6 feet in length, 4½ to 5½ inches in width, and ½ to ⅝ of an inch thick at the center, these dimensions somewhat exceeding those of the average sisal hemp leaf. The fiber is much lighter in color than sisal hemp; it is softer, and less brilliant, and does not compare with it in strength. Some years ago considerable quantities of the fiber were extracted commercially at Tequila, though the factory has since been discontinued. The product was employed as a substitute for the better kinds of cordage fibers, and as such could not command a high price. A very strong fiber is produced from a cultivated maguay in the region of Zamora, southeast of Guadalajara. It is known as Chavinda fiber and is used for cordage, chiefly, for local uses.

It should be noted that the fiber of all of these different forms of agaves, which are known as maguays, could be called maguay fiber, and as far as its commercial value is concerned it is, practically, all one and the same thing. While the fiber of *Agave Americana*, which I have considered the type, has been used in their domestic economy by the natives of all countries where it grows, it cannot be regarded, to-day, as a commercial proposition; and the same may be said of the other species whose fiber has found its way into the market in small quantities, with no regular demand, and filling no distinctive place other than a poor substitute for such fibers as sisal and manila.

But there is another fiber, known to commerce as "maguay," which is now being produced in the Philippines, comparatively small shipments of which have reached this country. The fiber should not be called maguay, however, as this plant appears to be more nearly allied to the sisal hemp agave, the fiber resembling the sisal hemp of commerce. The authorities of the Royal Botanic Gardens at Kew, England, have recently identified this species as *Agave cantula*. Mr. H. T. Edwards of the Philippine Bureau of Agriculture, publishes illustrations of the plant in a recent bulletin, showing the habit of growth, and form of leaf, from which a close resemblance to *Agave rigida* can be traced.

The Philippine "maguay" is described as having a short trunk; leaves from 4 to 6 feet long; from 2¾ inches wide at the base to 4 inches in the central portion, and an inch thick at the base (probably not over half an inch thick in the middle). The fiber is said to be finer, whiter and longer than Yucatan sisal—though it yields a smaller percentage of fiber to the weight of the leaf—yellowish white in color, 4 to 5 feet in length, fine, soft, and more wavy or fluffy than *abaca* or Manila hemp. It is not so strong as Manila, but is claimed to be stronger than common (Russian) hemp. From the characteristics of waviness and fluffiness, with elasticity, which are noted, it might be said to approach the maguay fiber, proper, of Mexico, but otherwise it is dissimilar. It may come between the fiber of *Agave Americana* and true sisal hemp.

The market value of Philippine maguay sent to London brokers in 1905 was $150 per ton, against sisal hemp at $185 per ton on the same date. Machine-cleaned Philippine maguay forwarded to brokers in New York city was reported to have approximately the same value as sisal. The fiber is usually quoted in New York, however, from one-half to three-fourths of a cent lower than sisal.

The plant is now known and employed locally throughout the archipelago; its cultivation is rapidly extending, and the exportation of the fiber steadily increasing. Six years ago the exports for the island amounted to but 875 tons, and they have more than doubled in four years. Until recently the fiber has been chiefly exported from the provinces of Ilcos Sur and Ilcos Norte, but Mr. Edwards states that in the past three or four years many planters in other portions of the islands have taken up cultivation, and the industry has extended to other provinces. In Cagayan over 650 acres of land are now planted in maguay, and in one town in Nasugbu there are 6,000,000 plants. Other provinces where the culture has passed the experimental stage are Union, Pangasinan, Zambales, and the islands of Cebu and Negros. As with the culture of sisal hemp in Yucatan and the Bahamas, a thin, rocky limestone soil, or one made up of partly decomposed coral rock, is best suited for the proper growth of the plant.

Cement for Steam and Water Pipes.—6 parts of powdered graphite, 3 parts slaked lime, 8 parts of finely powdered gypsum, mixed, and while adding 7 parts of boiled oil worked into a dough.

CONVERTING HOUSE REFUSE INTO FERTILIZERS.

THE hygienic and economical disposal of house refuse in large communities is a difficult problem. The heterogeneous nature of this waste, a large proportion of which is subject to objectionable decomposition demands that it shall be treated in such a manner, and so quickly, that the question of cost becomes a consideration secondary to that of the health of the inhabitants. The general practice to-day is to dispose of the refuse in destructors in conjunction with electric power-generating stations by means of which the fuel bill is somewhat reduced, and attempts are made to turn the resultant clinker to profitable account by pulverization and mixture with cement to form sidewalk slabs, and other building or paving material. In large cities, however, the quantity of clinker produced exceeds the demands for its utilization in this manner, with the result that the disposal of the waste becomes an expense.

At the same time, however, house refuse, owing to its extremely varied nature, is valuable as a fertilizer, but the presence of bottles, cans, pots, broken glass, cinders, and similar articles precludes its wide utilization in this connection. An interesting effort to surmount these difficulties, and one which has so far been attended with complete success, is being made by the Southwark civic authorities of London. A small plant has been laid down in which the refuse, with the exception of unusually large and bulky articles, is pulverized and mixed in the form of a finely-sifted soil, which possesses exceptional fertilizing qualities. The machine which accomplishes this function is known as the lightning dust manipulator, and has been evolved by the Southwark Engineering Works of Walworth, London. It comprises a high-speed centrifugal-force disintegrator, pulverizer and mixer combined, of extremely simple and solid construction, and which moreover only occupies a small area of space.

The refuse is dumped from the collecting carts direct into the hopper of the machine, the mouth of which measures 14 inches square, such articles as are too large to pass therethrough being cast on one side. From the hopper the heterogeneous mass falls into a small compartment in which revolve at high speed four special-alloy-steel horizontal swing hammers, each of which weighs over 50 pounds. These hammers revolve at a speed of 1,250 revolutions per minute, so that the material passing through the compartment is subjected to 5,000 strokes per minute from these four hammers representing a cumulative weight of over 250,000 pounds per minute without taking into calculation the impetus produced by the centrifugal force of the machine. The result is that the incongruous mixture of rubbish and offal comprising vegetable refuse, cinders, broken glass, paper, and other matter is disintegrated, pulverized and assimilated in one single operation, issuing from the discharge chute of the machine in the form of a dark black mold, the particles of which by the mechanical action of the machine are intimately intermixed, thereby forming an odorless manure possessing high fertilizing qualities, unobjectionable to either the eye or nostril, and not in any way injurious to the public health. Sometimes a few small pieces of white paper, which owing to their light texture have momentarily resisted the action of the machine, may be seen in the resultant product, but in the course of two or three days after distribution upon the land they entirely disappear. Should any articles enter the machine which are incapable of pulverization, such as pieces of steel or wrought iron, they are automatically thrown out by means of a special contrivance without reducing the speed of the machine.

At the Southwark refuse destructor works two of these machines electrically driven have been installed and occupy a superficial area of 30 x 50 feet. Owing to the simple nature of the plant the initial outlay therefor is very low while the current consumption for the motor is a small item. The manipulator deals with from 4 to 5 tons per hour with ease.

According to the official returns of the engineers to the Southwark municipality the cost of operating two of these plants is as follows:

	Per ton.
Electric power	16c.
Labor	14c.
Wear and tear	3c.
Oil, etc	1c.
Total	34c.

The cost of transporting the produced manure to the country represents a further 40 cents per ton, making a total expense of 74 cents per ton. The sale of the

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

fertilizer realizes 54 cents per ton, so that the net cost of reducing the refuse to manure has been 20 cents per ton. It must, however, be borne in mind that the plant installed at Southwark is purely of an experimental nature, so that it is not justifiable to consider the possibilities of the system from pioneer work. If the machines were laid down upon more scientific lines, and the output of each raised to its maximum capacity, combined with more economical procedure in regard to the electrical driving equipment and labor, the above cost would be very appreciably reduced, as has been shown in the case of other municipal authorities who have since adopted the plant. The market value of the fertilizer, now that its utility is being realized by agriculturists, can also be increased to a more remunerative price, the figure at present being 14 cents per ton at the depot. Increased price together with the economies possible in the operation of the plant will ultimately result in a distinct profit upon the sale of the product. The manure is capable of storage for an indefinite period without any deterioration, for when dumped in heaps the outer surface quickly becomes oxidized and provides an effective protective coating to the mass beneath. It can also be distributed easily and cheaply over the soil owing to its granulated condition either by hand or by mechanical appliances. A distinct advantage as compared with the ordinary classes of fertilizers is that it is entirely odorless, so that no offense is caused by either its transportation, storage in mounds in the open air, or distribution over the soil. It is conceded by the officials of the Southwark authorities that by the utilization of this system a simple, clean, and perfectly hygienic method of handling and disposing of house refuse at a profit is available. Owing to the success of this initial experiment the process is being widely adopted by other municipalities where the disposal of this waste is a difficult, vexatious, and expensive problem.

ANTHROPOLOGICAL CURIOSITIES.

THE PYGMIES OF THE WORLD.

BY ARTHUR H. J. KEANE.

In a very large number of cases, the dwarf is more vivacious, intelligent and long-lived than his ungainly, dull, and apathetic competitor for public favor. It is not the intention of the writer to deal here with the lives and peculiarities of renowned dwarfs, etc., who have, at more or less recent dates, figured on the public platform or in royal courts, such as General Stratton (Tom Thumb), Chung the Chinese dwarf, who was once exhibited together with Chang, the Chinese giant; Jeffrey Hudson (probably the most renowned dwarf that ever lived, and who was attached to the train of the Duchess of Buckingham in 1628), and many others. Men such as these are merely freaks, but it is our purpose to deal with tribes actually existing, or said once to have lived, that present peculiar and interesting features.

En passant it may be interesting to point out that while the Bible makes mention of several giants (of more or less amiable character), and gives the most minute details as to their huge proportions and marvelous strength of body, there is only one mention of a pygmy throughout the Sacred Scriptures, and then the reference is only general. The passage in question is in Leviticus, where the service of the altar is forbidden to all blemished persons, among whom "a dwarf" is included.

The subject of curious tribes and peoples is one which is surrounded with a great deal of legendary and fantastic data, as to the value of which the average man in the street (be he never so acute a business man) is quite unable to discriminate. A striking instance of this has just occurred in London, the press even having noticed the matter. There is a tradition that a race of pygmies once inhabited Mexico centuries ago, and the heads of the full-grown adults were said to be no larger than an ordinary hen's egg. Some of these tiny heads have now been brought to London, and were recently disposed of at a fancy price. Experts have been smiling broadly at this display of ignorance; indeed, on referring the matter to the recognized authority on anthropological matters, Dr. A. H. Keane, B.A., M.A.I. (late vice-president of the Anthropological Institute, etc.), he kindly writes: "The Mexican or Aztec egg-sized human heads are a myth or rather a hoax; nevertheless such heads exist. A South American tribe in Ecuador possesses the art of reducing any normal human head to the size of an ordinary orange while preserving the outlines and general features. This art they practise on the heads of their enemies captured in war and, like the Dyak head hunters, preserve them in this form as trophies. Some of these latter have now been got hold of by 'knowing ones' and they are turning an honest penny by exhibiting them as the veritable heads of an extinct diminutive race in Mexico. These dwarfs are about as authentic as Gulliver's Lilliputians." This is worthy of note, as it may safely be assumed that, as these heads are being got hold of, they will sooner or later be offered for sale to American collectors.

Let us now come to genuine "little people," whom we may term "pygmies"—this being the description used for the living and extinct dwarfish races of mankind. Prof. Windle says that "any race in which the average male stature does not exceed 4 feet 9 inches, may fairly be described as pygmy." Actual dwarf races are well typified by the African Akkas encountered by Sir Henry M. Stanley, the average height of their men being about 4 feet. Smaller men still are known to have existed closer home, however; the dwarf skeletons found at Schaffhausen in Switzerland, and described in 1894 by Prof. Kollmann, of Basel, only averaged about 3 feet 6 inches. There is scarcely a quarter of the globe where some traces of pygmies are not found. De Quatrefages regards southern Asia as the home of the famous black dwarfs or negritos (of which we speak further on), whence they spread through Melanesia and Africa. The Andaman Islands, the Philippines, and New Guinea all have their pygmies (Mincopies, Aetas and Karons respectively), while several dwarfish tribes are found in the Malay Peninsula. Capt. Cayley Webster reports a dwarf tribe in Woodlark Island (off the extreme east of New Guinea), and Prof. Haddon has craniological evidence of a former dwarf population on the shores of Torres Straits. Chinese records speak of black dwarfs in Shan-tung, who apparently spread northward into Japan; finally De Quatrefages states that black dwarf tribes seem to have been aboriginal near Lake Zerrah in Persia.

Mr. Clements Markham states, on good authority, that in Central and South America the Guayazis and Cauanas are two dwarf tribes inhabiting certain districts of the Amazon basin, the latter tribe having an average stature of 3 feet 6 inches.

At the present time Africa is essentially the home of the pygmies, of which it contains the greatest number and variety. Paul du Chaillu encountered the Obongo dwarfs in 1865, but the dwarfs of the Congo region were described as long ago as 1625 by an English sailor (Andrew Battel) who lived in their country for eighteen years. Sir Harry Johnston describes these dwarfs as often very apelike in appearance. Their hairy skins, the length of their arms, the strength of their thickset frames, their furtive ways, and their arboreal habits all point to these people as representing man in one of his earlier forms. A company of these Congo pygmies were exhibited in London in the summer of 1905.

Of all dwarf tribes, however, perhaps the most interesting and important are the black dwarfs or negritos casually mentioned above. The characteristics of these little people may be summed up as follows: Generally dark color; very short, black woolly hair; extreme prognathism; low stature ranging from 3 feet 6 inches to 4 feet 10 inches; disproportionately large brachycephalous (short) head; very slender legs with undeveloped calves; the quick, fitful temperament of children; extremely low culture, shown by the absence of fixed abodes, and of all arts, clothes, religion, and implements excepting the bow and arrow in the use of which they are very skillful. If let alone they are of mild and harmless disposition, but it has been found impossible to tame them. Some of the fullest details as to these pygmies have been published in "Man Past and Present," by Dr. A. H. Keane, a work which has attracted world-wide attention and commendation.

This writer says: "The proper domain of the African negritos is the inter-tropical forest land, although they at present appear to be confined to somewhat narrow limits, between about six degrees north and south of the equator, unless the Bushmen be included. But formerly they probably ranged much farther north, possibly in Neolithic times accompanying their big brothers into central Europe (Switzerland), and in historic times finding their way down the Nile valley to Egypt, where they were certainly known some 4,000 or 5,000 years ago." This is evident, the same writer points out, from the frequent references made to them in the "Book of the Dead" as far back as the sixth dynasty. They were very popular as dwarfs at the court of the Pharaohs, and expeditions used to be dispatched to bring specimens home. The first one of whom there is authentic record was brought to the court of King Assa (3300 B. C.), and 70 years later Pepi II dispatched an officer to bring him a similar pygmy. The Romans also were admirers of dwarfs; the Emperor Augustus had one in his train named Lucius, who only weighed 17 pounds (it is said), while his height was only a little over 2 feet. This was probably also a young negrito.

But enough on this score, as we have other matters to record. Advices lately to hand from Adelaide (dated November 7) state that Prof. Klaatsch—a Heidelberg anthropologist now in Australia—has concluded his researches in New Guinea and Queensland, and is now in the northern parts of the country, the interior of which is still unexplored. He is studying the manners, customs, and genealogical descent of the Australian negroes, and has made a very remarkable discovery.

A short time ago a white trader was attacked and killed by natives while in his boat at Port Keats. The murderers were discovered and arrested, and are now awaiting trial. Prof. Klaatsch at once examined these men and, to his astonishment, found that one of them had ape-like feet, i. e., the feet are hands and are perfectly similar in every detail to the lower extremities of an ape. The blacks vigorously asserted, when questioned by the professor, that there are "many, many black fellows" with similar feet in the unexplored regions comprised between the Daly and Victoria Rivers, and Prof. Klaatsch is now taking steps to verify these statements. This is the first time such a formation has been found in the feet of an Australian negro; Prof. Semon, Prof. Lumholz, Dr. Lauterer, and others have noticed the great prehensile power of the toes, which gives these blacks a greater skill in climbing than any people on the earth, but they never found anything abnormal in the actual structure of the feet during the many years they spent among the Australian blacks.

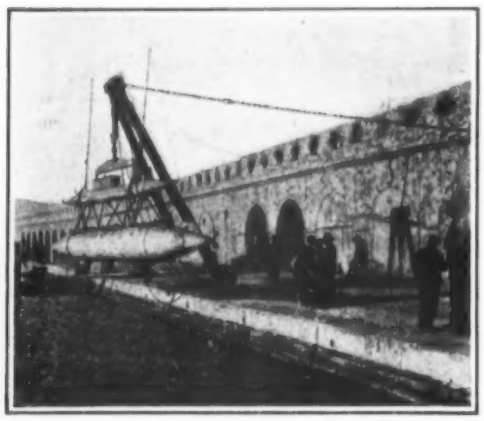
An interesting find has recently been made at Kusseri (Cameroon), where reports say that there was once a race of giants. One of their assumed cemeteries was recently opened, and two large earthenware pots were found—one buried with the aperture upward while the other faced downward. Dr. Freyer, surgeon-in-chief at Kusseri station, was present when these finds were made. The pots were of a type which none of the natives are now capable of making; besides nowadays bodies are stretched out at full length for burial, while the old giant fashion was to place the body in a hole crouching with the knees drawn up to the chin, and then push one of the large pots down over it. The pots were shaped like a bomb-shell with the edge or lip of the aperture turned outward; the color was yellowish brown. The first pot contained earth and fragments of bones, many of which were easily recognizable, viz., spinal vertebræ, ribs, a piece of shin-bone, lower portions of the right and left femur, etc. In the second vase there were several teeth, remains of beads, etc. If these vases and their contents really originate from the time when giants inhabited the land, then the only conclusion that can be deduced from these bones is that the "giants" buried did not possess unusually large bones, those found being apparently from the skeletons of ordinary adult human beings. Lieutenant Schipper, the resident at Kusseri, states that the belief in the old-time giant people is deeply rooted in the natives' minds, and the find is therefore by no means uninteresting, especially as the mode of burial adopted is one to which the country is quite unaccustomed and one which is said to have been peculiar to the legendary "Ssau" giants. As the urns found are very similar to the colossal vases (also attributed to giants) found at Ngala, Ndusu, etc., they doubtless belong to the same period, which gives the deathblow to the giant legend. This has, undoubtedly, arisen from the wonder awakened in the native mind by the enormous size of the pots which are assumed to have been used solely for burial purposes, whereas they were probably used as receptacles for the collection of water. Be this as it may, the fact remains that there are enormous mounds here dating from distant ages, for which no explanation can be found, while finds are made now and again of unusually large leg bangles, which the natives assert were used as ornaments by the giant ladies in times gone by. In spite of this the opinion is held that the existence in Cameroon of an old-time race of giants is not proven—a verdict also shared by the French savant, Dr. Decorse, who investigated the question locally some three years ago.

The old adage that "the proper study of mankind is man" (perhaps we ought to say "woman" to be polite—and truthful?) is here borne out to the full; money and fame await the successful explorer and investigator who strikes out on the unbeaten track. The foot of the ladder is always crowded, but there's more than elbow room at the top.

A TORPEDO GUIDED BY ELECTRIC WAVES.

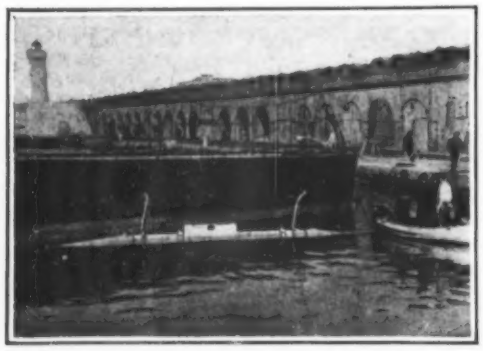
A NAVAL POSSIBILITY.

THE attempts made in 1898, by Orling at Stockholm and Armstrong at Portsmouth, to control torpedoes by wireless transmission of electric impulses have led to no practical result. Since then a company has been formed in France for the study of the subject, and experiments have been made at Antibes with a torpedo which is kept immersed at a constant depth by means of a float, which bears the apparatus for the



THE TORPEDO AND ITS FLOAT SUSPENDED FROM A CRANE IN THE HARBOR OF ANTIBES.

reception of aerial waves. This apparatus includes a device by which the different signals are caused to operate the propelling and steering apparatus of the torpedo without mutual interference. The device here illustrated is the invention of Gabet, a young French engineer, and has given very satisfactory results. The electric circuits which govern the various operations—increasing and reducing speed, turning to right and left, etc.—are so arranged with reference to a sort of paddle wheel that each circuit is closed by bringing the corresponding blade of the wheel into a horizontal position. The wheel is driven by a pawl attached to the armature of an electro magnet, each closure of the magnet circuit bringing the second blade of the wheel, for example, into the position formerly occupied by the first blade. Hence, by tapping the magnet key and sending short impulses like those which correspond to dots in telegraphing, the operator can bring the blades successively into the nearly horizontal or contact position and stop the rotation when the desired blade has reached that position. But although, in general, several other blades have been brought into the contact position in this process, the actual closure of the corresponding circuits is prevented by the following ingenious device. Each blade carries a serpentine glass tube which contains a little mercury. When the blade is above the axis the mercury is collected at the end of the tube which is nearest the axis, but it flows to the peripheral end of the tube when the rotation of the wheel carries the blade below the axis. Now if a blade is arrested at the contact position, in which it is very slightly inclined downward, the mer-



THE TORPEDO IN THE WATER, SHOWING FLOAT BEARING MASTS AND ANTENNÆ FOR THE RECEPTION OF AERIAL SIGNALS.

cury flows slowly through the long curved tube from the inner to the outer end, which it must reach in order to effect the closure of the corresponding circuit. The transit occupies about five seconds. Hence if the successive impulses which rotate the wheel are made at intervals less than five seconds, none of the circuits which operate the torpedo is closed until the desired blade has reached the contact position and has been allowed to remain there longer than five seconds. Each operating circuit terminates in one of the rings shown on the axis of the wheel.

With a wheel of eight blades, two of which are used to make and break the circuit of the magnet which drives the wheel, the torpedo can be influenced in six ways. Thus, its motor can be accelerated, retarded, or stopped, and its rudder turned to right, to left, or straight astern. The arrival of each blade at the contact position is instantaneously made known by the lighting of an electric lamp, so that the operator on ship or shore can follow the operations, and he has five seconds in which to correct a mistake in signaling.

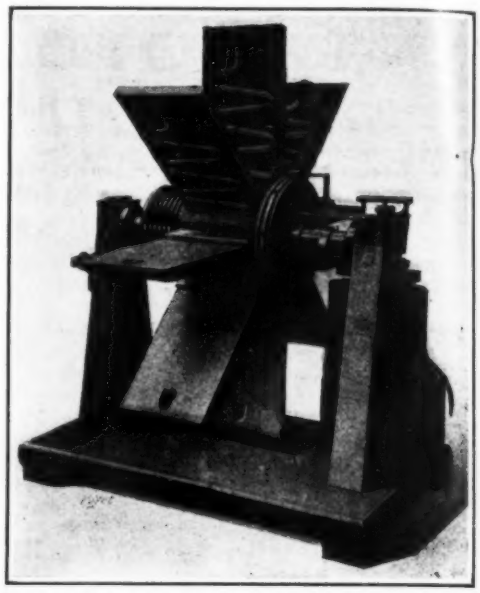
Greater precision in guiding torpedoes to their goal has been attained by this wireless electric method than by any other system yet devised. The same method is evidently applicable to the control of machinery at a distance in factories, in air ships, on railways, etc.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

ELECTRICAL EXPORTS.

THE electrical export trade has continued throughout the past year to exhibit many signs of healthy progress, and the returns now available for May indicate that the whole twelve months will reach a high level. During May the exports of heavy electrical machinery were $800,566 as compared with $681,955 last year. For the 11 months, the total is $7,924,806 as compared with a previous $7,229,576 and $6,661,676 in 1905. In like manner the export of electrical instruments has shown a gratifying increase for the whole period, although May itself fell off somewhat. The exports of this class last May reached $619,393, while in 1906 they were $709,875. But for the 11 months they were $7,508,364 as compared with $6,115,254 and $4,490,818 in the periods corresponding, of 1906 and 1905. For the 11 months therefore the total export of electrical apparatus has attained the respectable figure of not less than $15,433,170, and it bids fair for the whole fiscal year to reach about $17,000,000. Large as this may seem, it is, however, below 10 per cent of the total production in this country of electrical goods, and from this point of view a good deal of effort can be put, and ought to be put, in the development of fuller trade relations with countries that are still in the list of "prospects." The United Kingdom, Mexico, British North America, and Japan are our best customers for heavy machinery, and with them again, Brazil is a good patron of our electrical instruments. Under present tariff conditions there does not appear to be much to expect from growth of relationships with Continental Europe, but South America, the West Indies, Asia, and the Far East are as open to us as to the rest of the manufacturing world; and there are huge, unsatisfied wants in all of them. Many of these countries without cheap fuel have fine water powers, and Mexico has shown how large a demand may be created by the latter. Recent years have seen also the production of large classes of detail apparatus for industrial and domestic use, which, serviceable in temperate climes, will eventually become indispensable in tropic and sub-tropic regions.—Electrical World.

THE PROPERTIES OF ELECTRONS.

IT is a significant indication of the close connection between physical science and its application, that President Samuel Sheldon's recent address before the American Institute of Electrical Engineers was devoted entirely to a subject of recent physical investigation—the properties of electrons. The paper is useful to the electrical engineer, because it forms a compilation of the most essential facts at present possessed concerning electrons, expressed in electrotechnical terms rather than in the language of physicists. The paper refers to the fact that the mass of an electron appears to be entirely electromagnetic. In other words, the only kind of inertia possessed by the ultimate particles of matter is their electromagnetic inertia, or the inertia of the self-induction of virtual electric currents, due to the motion of the electric charges which constitute electrons. When an electron is stationary with respect to its surrounding ether, the electric flux from its charge radiates uniformly in all directions and there is no magnetic flux developed. The stresses due to the radiating electric flux balance in all directions, or produce no resultant force upon the electron. When, however, the electron moves, the cutting of ether by the electric flux generates magnetic forces and these forces pull upon the electron. The distribution of electric flux emerging from the electron is also disturbed. It weakens ahead of the electron and intensifies in its wake. This causes a resultant electromagnetic force to pull back on the electron during



THE PADDLE WHEEL SIGNAL DISTRIBUTOR. (EIGHT BLADES.)

acceleration, with an intensity proportional thereto, or in accordance with the Newtonian law of inertia. Work of an electromagnetic kind has, therefore, to be done upon any and every electron during acceleration, owing to its self-induction.

A mass of one pound is supposed to contain about 7×10^{26} electrons, or 7 followed by 29 zeros. The mechanical force of inertia of the pound weight, when moved suddenly, is supposed to be the total electromagnetic force of inertia of that horde of electrons. The only difference between the electromagnetic inertia theory of matter based on electrons and the mechanical inertia theory of Newton, is that the mechanical theory takes it for granted that inertia is constant at all velocities, or is independent of velocity, so that a projectile should resist acceleration to the same extent, whether at rest, or already moving at a speed of half a mile per second; whereas the electromagnetic theory requires that the inertia of the projectile should increase with the speed, and become infinite at the speed of light. Practically, there is no discrepancy between these two theories within the limits of artificially producible speeds so far as experiment is likely to discover. In other words, the increase of inertia in a projectile fired from a large cannon would be quite insignificant, because its velocity is so small compared with that of light. The great potential importance of the electronic theory is not merely that it can explain inertia and the unity of all matter, but that it may in time lead to the comprehension of all chemical action. At present we know, for instance, that carbon and oxygen can combine with a disengagement of thermal energy, but we have no idea of why a

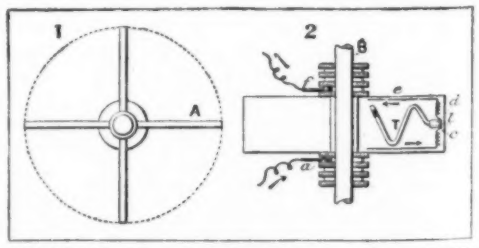


DIAGRAM OF A DISTRIBUTOR WITH FOUR BLADES.

carbon atom attracts oxygen atoms, how the combination occurs, or how heat is liberated in the process. Chemistry is mainly the name of a very long list of observed facts concerning the relative behavior of different substances, the ultimate nature of the substances and of their reactions being unknown. If, however, the electron theory can be highly developed, and if atoms of all kinds are mere groupings of electrons, we ought to get to understand how these different atoms must behave toward each other, and so,

perhaps, predict chemical phenomena. Another great utility that may exist in the electron theory is in the working of metals in such a manner as to increase the number of free electrons, or the degree of freedom of such free electrons as ordinarily exist therein. By this means, we should expect to increase the electric conductivity of the metals, or diminish the size of wire that would be necessary for carrying a given power to a given distance with a given loss. Of course, it may be said that metallurgical experiments are more likely to be practically useful in this direction than electronic theory; but, on the other hand, it is readily conceivable that the electronic theory, if sufficiently developed, might suggest experiments that would otherwise not be thought of.—Elect. World.

WIRELESS TELEGRAPH APPARATUS FOR THE LECTURE ROOM.

HOW IT SHOULD BE CONSTRUCTED.

BY AUGUSTUS B. TRIPP.

In view of the fact that a lecture on almost any subject is much more interesting when accompanied by illustrations or experiments, a lecturer on wireless telegraphy has constructed for his own use a set of portable instruments with which many interesting experiments may be performed. The apparatus, when packed, is in such a form that the lecturer and his assistant may readily carry the instruments, and thus avoid intrusting them to the tender mercies of the baggage car and the expressman.

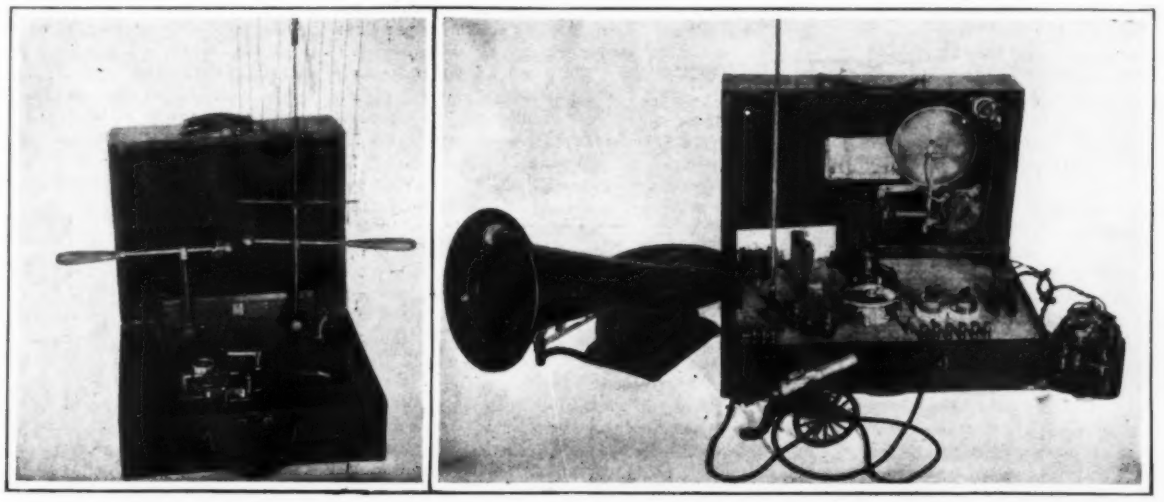
The transmitter is inclosed in a case which, when closed, measures about 15 x 12 x 9 inches, and is composed of a transmitting coil, strap, key, batteries, and a fire alarm box, which may be pulled so as to send in from one to four rounds. It also has a thermostat so arranged that the heat from a lighted match will turn in the alarm. The receiver is in a case 19 x 12 x 6 inches. It contains the coherer, decoherer, relay, and batteries. The photograph shows that in addition to the usual sounder or register, there are two bells, one of which is used for the Morse signals, seen in front of the case, and the other for the fire alarm, seen in the cover. At the left is shown the phonograph, which is started from the transmitter, while directly in front of the receiver is a cannon which is also discharged by wireless. At the right front are the binding posts used to connect the apparatus with the electric lighting service.

During the first part of a demonstration or lecture it is not advisable to have these lighting wires connected, as an audience is very suspicious of any wires running to the electric light fixtures or other permanent wires. For this reason it is preferable to send Morse signals, start the phonograph, and fire the cannon, so that the audience will be satisfied that the instruments will operate without any outside connection, but from the energy of the battery within their cases. The apparatus may then be connected to the lighting service, and lamps lighted or extinguished. An electro-magnetic switch is used to turn the current for the lamps off and on; by means of this switch a system of warning signaling for lighthouses is easily shown.

A fire alarm system is shown by turning in an alarm at the transmitter and having it caught, and the box number rung out in single strokes by the receiver. In this way the operation of the single pieces of apparatus is readily shown. The instrument, however, is able to perform all of these operations at once. In addition to the things already mentioned, a small American flag is held at the bottom of the aerial until magnetically released. A drop light is hung over the aerial rod, so that it will shine on the top of it, and an electric fan is so arranged that the breeze which it produces will blow on the top of the aerial also.

By throwing the switch in the left-hand corner of the case, five different operations are performed at the closing of the transmitter circuit for a single instant: First, the flag is released, and is drawn to the top of the rod by means of a weight; second, the drop light shining on it is lighted; third, the fan is started and the flag waves in its breeze; fourth, the rest of the lights in the room are turned out; fifth, the phonograph is started and plays the "Star-Spangled Banner." This last experiment is one which is greatly appreciated by most audiences.

The next closing of the transmitter circuit relights the assembly hall. When conditions permit, the photograph of the audience is taken. The spark from the transmitter causes the receiver to open the camera shutter, explode a flashlight, and then close the shutter. The photograph of the receiver was taken by wireless.



PORTABLE TRANSMITTER. RECEIVER WITH VARIOUS APPARATUS ACTUATED THEREBY.

WIRELESS TELEGRAPH APPARATUS FOR LECTURE PURPOSES.

THE INTERPOLE MOTOR.

THE interpole construction has already won a good reputation in stationary motors intended for a wide range of load and speed. The fundamental idea of counteracting the armature field by superimposing upon it an opposed magnetomotive force is an old one, and the recent interpole construction is novel more in detail than in principle. It is natural to expect benefits from an application of the same principle to railway motors, and the only wonder is that the announcement of interpole traction motors made recently at Niagara Falls and Lake Champlain was so long delayed. The papers by Messrs. Anderson, Hill, and Renshaw, which we have already placed before our readers, put the principles involved very clearly and give good reason for some confidence in the excellence of the results. It must not be supposed, however, that the commutating pole is a panacea for all the ills that motors are heir to. As in the case of compound winding of generators, there are limits to be faced, and one can neither invoke compounding to remedy bad design nor to increase indefinitely the overload capacity. Intelligently applied, it is extremely useful and important. Just so with the commutating pole; it can do much but not everything, and it must be wisely applied and carefully designed in order to produce the best commercial results. It has some conspicuous virtues and a good many "talking points" to its credit.

Until the latest light broke upon us, we had, however, been under the impression that in recent railway motors sparking had been pretty thoroughly eliminated, so that heating was the thing which set a limit to good performance. We hardly know whether to confess our error and retract or not. Would we become the more beloved by taking the one horn of the dilemma or the other? With all seriousness, we are convinced that the interpole motor is theoretically excellent and practically very useful in certain cases. How thoroughly its range of applicability covers the field of electric traction remains to be shown by practice. It should seemingly make it rather easier to construct motors for high voltage, yet the maximum of 1,700 volts for a 250-horse-power motor with an 18-inch commutator is not a very startling *denouement*. M. Thury has already built a number of generators of similar output, six-pole machines at that, which are reported to give excellent commutation. It will doubtless prove somewhat easier to build a compact, high-voltage motor with commutating poles than without them, and for this gain there is good reason for congratulation. The coming of a practical and reliable large railway motor for 1,500 to 2,000 volts will certainly put a new face upon the heavier railway work. However well the single-phase commutating motor may turn out, we doubt whether even its most enthusiastic friend expects it to run with as perfect commutation as can be obtained in a d. c. motor of similar weight and output. The question is rather whether the a. c. motor will commutate satisfactorily considering its other advantages.

The future of the interpole motor—so far as heavy traction is concerned—must be determined by its own performance. A three-wire system worked on a four-motor equipment arranged in pairs, with 3,000 to 4,000 volts between the outside wires, would be an important addition to our means of heavy traction. It would give a thousand horse-power with hardly 300 amperes input, an amount of current that can be managed without great difficulty even from overhead conductors. For high-speed work it would be feasible, as Mr. Anderson indicates, to raise the voltage per motor even higher. With 5,000 volts between the outside wires, the gain in distribution would be so great as to push a. c. operation hard, and especially if it be considered necessary to drop the frequency to about 15 cycles to get the best operating conditions.

This subject was also discussed at the Institute meeting, but until more operative data from large single-phase motors are available this question of frequency must be considered an open one. Certainly few engineers would wish to go to 15 cycles if good operation could be attained at 25. The commutating pole d. c. motor with its possibility of somewhat higher voltage most effectively strengthens the hands of engineers who, like Sprague, Parshall, and Hobart, look with distrust on commutating single-phase motors. As we have many times intimated, high voltage on the working conductors is the desideratum in heavy electric traction; how it gets there and how it may be utilized are matters of minor importance. If the commutating pole construction can put 3,000, 4,000, or 5,000 volts at our command with a simple and efficient motor equipment, a long step in advance will have been taken. It is now up to the builders of such motors to put them into active service and prove their virtues on a commercial scale.

The commutating pole motor is now also being built in considerable quantities for ordinary voltages. For this purpose it possesses many advantages over the

older type, and while flashing over may occur, it is thought that by removing the incipient cause—sparking under the brush—together with copper and carbon dust, the chances of its occurrence would be greatly reduced. But although the gain in motors for ordinary voltage from this construction may be very material, it is insignificant compared with the possibilities in the larger sphere of electric traction.—Street Railway Journal.

UNSOLVED PROBLEMS IN THE DESIGN AND PROPULSION OF SHIPS.*

LOADING, WATERTIGHT COMPARTMENTS, AND STABILITY.

BY FRANCIS ELGAR, LL.D., F.R.S., M.INST.C.E.

THERE are but few problems in the design of ships, as in most other branches of engineering, that can be exactly or completely solved in the full scientific meaning of the word, and those are of a secondary character. The primary or fundamental problems of safety, strength, speed, and steadiness at sea are far too complicated to bring under anything like general mathematical treatment. The results obtained by the most advanced calculations cannot be applied directly to the real conditions of a ship at sea. After all is said and done, they merely relate to hypothetical cases which are simple in character, and happen to be amenable to mathematical treatment. Some of these calculations are very elaborate, and their elaboration may tend to magnify their importance. The real problem is often very imperfectly dealt with after they are made; and it can only be solved approximately for working purposes by accepting the results of calculation for what they are worth, judging of the allowances required for their incompleteness, and using them in a scientific way and a scientific spirit to arrive at safe conclusions. We are obliged to come to a definite conclusion somehow, because we have to build ships as well as we can, whether we can solve exactly all the problems that arise in their design or not; and we have to take the responsibility of guaranteeing results, however difficult they may be to obtain, within the time allotted for the preparation of designs and tenders, which is often very short. This is of the nature of engineering work of all kinds. To quote from our president's excellent inaugural address, "Engineering problems differ from ordinary academically 'scientific' problems, partly in that they are much more complex, and consequently more difficult of anything like exact solution, and still more because—exact or inexact—some solution to them has always got to be found."

The nature of some of the principal problems that arise in the design of ships, and the extent to which their solutions are scientific, empirical, or merely tentative, will be indicated to some extent as I go on. I pass over what I venture to call the secondary problems of mensuration and hydrostatics—which relate to bodies floating in equilibrium in still water, and constitute the bulk of the ship designer's purely scientific stock-in-trade—and will endeavor to direct attention to some of the fundamental problems of a ship's behavior at sea. I do not underrate, however, the great importance of those now passed over, for it is the results of mathematical and physical research into the still-water properties and conditions of floating bodies which alone enable us, with the aid of observation and experience, to judge correctly the probable qualities and behavior of ships at sea. They also furnish the best data for comparisons between ships of varying dimensions and forms.

The class of problems that demand attention first are those which bear the most directly upon safety at sea. These are very general and comprehensive in character, and are impossible of anything like complete solution from the purely scientific side; but they are of vital importance, and solutions of them, which are, at any rate, upon the right side, have got to be found somehow for every ship that is built.

DEPTH OF LOADING.

The first in natural order of the problems that relate to safety is the maximum depth of safe loading, or the minimum sea-going free-board for a ship of any given size or type. Nothing ever caused more trouble in the shipping world than the arriving at an empirical solution of this vital problem some twenty years ago, and obtaining general acceptance for it. In the old days of sailing ships, and the early days of steamers, a standard number of inches per foot depth of hold was the ordinary simple rule for fixing free-boards, and that gave, on the whole, fairly uniform and satisfactory working results down to a certain time. But after the old rule of tonnage measurement, which merely took account of length and breadth of ship, was finally superseded by the present system of making internal capacity the measure of tonnage, types of cargo-steamers grew up which varied materially in proportions and form according to the trade in which they were employed, or the ideas of their designer. These diversities of type were promoted by the ever-increasing commercial competition among shipowners, so that the question of the maximum depth of safe loading became more and more as time went on, one which depended upon special features and characteristics of particular ships or types of ships.

The losses of cargo steamers and of lives at sea became so serious 25 to 30 years ago that many attempts were made to get a law passed for limiting depth of loading. The great difficulty and complexity of the problem resisted all efforts for a long while to deal satisfactorily with it. It was considered by many authorities, upon all sides, to be impossible of solution. And yet it was obvious that each individual shipowner, or shipping company, however many ships he, or they, might control, was obliged to regulate the loading in some way, and upon some system or make it the duty of others to do it. It followed, therefore, that if the knowledge and experience of those separately responsible for the loading of the various types of vessels could be brought together and analyzed, it ought to be possible to frame rules and tables of freeboard which would embody the results of safe loading, and prevent steamers being sent to sea in a dangerously overladen condition.

The present Board of Trade freeboard rules and tables, which limit, by an Act of Parliament passed in 1890, the depth of loading of British ships, were arrived at in this manner. The first official tables were prepared in 1885 by a committee appointed by Mr. Chamberlain when he was president of the Board of Trade. They were based mainly upon data which Mr. Martell, the chief surveyor of Lloyd's Register Society, collected, analyzed, and put into the form of tables. The Board of Trade committee obtained much additional data, and brought Lloyd's tables up to date, both in respect of figures for freeboards and allowances for variations from standard types and dimensions. The committee's tables were officially adopted, and freeboards regulated in accordance with them were accepted by the Board of Trade. In the year 1890 they were made compulsory upon all British ships.

The freeboard rules and tables of 1885 applied only, of course, to the then existing classes and types of ships. Rapid developments went on in size, and in distinctive types of cargo boats, so that extensions and modifications of the original tables became necessary at times, in order to provide for altered conditions. The statistics of loading have also become much more complete as experience has been gained, and have shown where corrections could be made with advantage. The principal alterations and additions were made in 1898, as the result of recommendations to the Board of Trade by a second Departmental Committee; and further corrections have been applied from time to time at conferences between the Board of Trade and representatives of the classification societies, to whom the duty of assigning freeboards is intrusted.

The real problem to be solved in fixing freeboards is that of the height of side above water which is requisite in order to prevent seas breaking upon the deck so heavily as to overcome the protection of the deck openings and find their way below and also to enable the officers and crew to work the ship in safety from the deck in the worst weather. One of the most important factors is strength of deck, and efficient protection of deck openings by high casings and strong well-covered hatchways. Many of the worst losses occurred through imperfect protection of deck openings. Hatchway coverings, or light houses on deck which inclosed openings, were carried away, large bodies of water passed below in increasing quantities as the seas swept over the ship, and she ultimately foundered. There have been cases where the tops of the openings into the stokeholds were only about a foot above the freeboard deck, and heavy seas got down through them, put out the fires, and gradually sank the ship. It is now usual to protect the engine and boiler hatches by casings which are carried up a deck higher than the weather deck to which the freeboard is measured; and the standard freeboards are only assigned to ships in which the engine and boiler casings above the upper deck are of sufficient height and strength, and which have all their weather-deck hatchways properly and substantially framed and securely fitted with strong covers.

The close attention paid during recent years to the protection of openings in the weather deck, in association with the strict limitation of loading now enforced by the Board of Trade freeboard tables, has resulted in an extraordinary diminution of losses at sea. The effect upon safety of the present regulations, and of the improvement all round in the size, strength, and equipment of ships, is shown by the yearly statistics of losses; and it is well that the figures should be generally known. In the three years 1881-3 there were 1,982 British ships, registered in the United Kingdom, exclusive of fishing vessels, lost at sea from all causes—foundering, stranding, collision, and missing—and 5,599 lives of crews in them, besides 332 passengers. For the three years ending 30th June, 1906, the corresponding figures are 654 ships, 1,394 lives of crews, and 133 passengers—and over 100 of these passengers were lost in the channel steamer "Hilda," on her passage to St. Malo in November, 1905. The number of lives of crews lost at sea has thus been reduced to one-fourth of what it was 25 years ago; while not more than thirty passengers besides the unfortunate victims of the "Hilda" disaster lost their lives in all the vessels, large and small, that were lost at sea during the three years ending 30th June, 1906. If we consider merely the cases of foundered and missing ships, and omit those lost by stranding and collision which do not directly affect the ship designer, and also omit all small craft below 300 tons gross register, as well as fishing-vessels and yachts, the results are as follows: In the three years 1881-3, 264 ships and 3,006 lives of crews; in the three years ending 30th June, 1906, 55 ships and 670 lives of crews. The figures here given are for steamers and sailing-ships. If those for sailing-ships could be taken out, they would show still better for steamers, as the percentage of losses to those carried in sailing-ships remains about the same. The great reduction has been in steamers. It will thus be seen that however empirical and tentative the procedure in this matter may necessarily have been, the result is a very large and gratifying saving of life and property at sea.

WATER-TIGHT COMPARTMENTS.

An important element of safety at sea is that of the division of the hull into separate watertight compartments. A collision with another ship may happen, and it is necessary to provide, in such case, against being sent to the bottom. Much attention has been given to this point during recent years, especially in the large passenger liners. The number and positions of the watertight bulkheads in these are often regulated so as to carry out the recommendations of the Board of Trade Bulkheads Committee, presided over by the late Sir E. J. Harland in 1891. The problem was how to subdivide large ships so that they may float in moderate weather with any two compartments in free connection with the sea. The solution adopted by the Bulkheads Committee was to so place the bulkheads in large liners, and in all cross-channel passenger steamers, that when any two adjacent compartments are laid open to the sea, the uppermost watertight deck to which the bulkheads extend, called the "bulkhead deck," is not brought nearer to the water surface amidships than 3 per cent of the depth of the ship below that deck, and at the ends not nearer than 1½ per cent. The arrangement of bulkheads necessary to satisfy this condition can be determined by calculation for any particular ship, with proper allowances for the displacement of the contents of engine and boiler rooms, holds, etc., or it can be fixed sufficiently near for practical purposes by reference to curves and tables appended to the committee's report, which gave the spacing of bulkheads for standard cargoes. The case of any two compartments freely open to the sea, in which the ship's pumping power would be of no avail, is so extreme that the Bulkheads Committee's solution of this problem evidently provides a margin of safety in the event of accident.

Compliance with the Bulkhead Committee's rules is optional on the part of shipowners; but, although they may be sometimes used as a guide in fixing the position of bulkheads, full compliance with their requirements is by no means general even in the highest class of steamers.

STABILITY.

The next point of vital importance to safety at sea is stability. The stability of a ship when floating in equilibrium in still water is readily calculated, and is represented graphically by curves which show at any

* The James Forrest lecture, delivered before the Institution of Civil Engineers, June 18, 1907.

angle of inclination what the righting moment is which operates to move her back toward the upright position, supposing her to have been forcibly inclined away from it. These are called curves of stability; and they are usually made for several critical conditions, such as the light condition, the condition for drydocking, the fully-laden condition, assuming the bunkers full of coal and all the cargo spaces to be filled with homogeneous cargo of a density that immerses the ship to her load waterline; and also the last-named condition, after all coal, water, and consumable stores are exhausted, with any other conditions that may require special attention. The stability of the ship is thus known very completely for still-water conditions; but her designer, although he is obliged to trust to his judgment for making it satisfactory for sea-going purposes, often knows little of what it may become under working conditions upon a voyage. I made two voyages in a large ocean liner not long ago, whose metacentric height is about 7 inches when quite light, and 18 inches when filled up with passengers, stores, fresh water, coal, and a homogeneous cargo of such density as completely fills all the cargo spaces and immerses her to her load draft. I estimated the weights of cargo, coal, water, stores, and passengers on board at the time of sailing, and the heights of their centers of gravity, and corrected the figures from day to day during the voyage as coal, water, and stores were consumed. The results were that at sailing the metacentric height was 2 feet 2 inches, at the middle of the voyage it was 21 inches, and at the end of the voyage it was 20 inches. Upon the second voyage the metacentric heights were 2 feet 10 inches at starting, 16 inches in the middle of the voyage, and 20 inches at the end. The irregularities in the metacentric height from day to day were due largely to the manner in which the water ballast was used. This was the case of an ocean liner, in which the weights carried were about one-half the fixed weight of the hull and machinery. In a large cargo steamer, where the weights carried amount to twice the weight of the hull and machinery, it will be seen how much her qualities in respect of stability when loaded depend upon those who regulate the loading, and how little upon the designer.

The ship designer requires to decide, of course, what metacentric height to give a ship in the circumstances to which his calculations apply; but it is only by comparison with other ships of similar types that have been found satisfactory after passing into the hands of their owners that he can properly fix the precise figure. In passenger liners the righting moments at large angles of inclination are always great because of the high side above water, and the position of the center of gravity. Even if the metacentric height were to become *nil* in their case, they would only incline to one side or the other; there would be no serious risk of capsizing. The case is different with many cargo-steamers, and was very different twenty-five years ago with a class of steamers that were largely engaged in carrying grain and coal cargoes. These were so constructed as to enable them to load with cargo to the under side of the upper deck, but they had insufficient beam to give a safe margin of stability when so laden. They were safe enough if only light cargoes were placed in the 'tween decks, or when these were but partially filled; but when they were filled up, as often happened, with homogeneous grain cargoes, the metacentric height came down to 6 inches, or even less; and with their low sides, combined often with shifting of cargo in bad weather, the number lost by taking a heavy list and foundering at sea was very large. This class of ships formed an important item in the tragic list of losses of the early eighties.

The question of stability was raised at the Load-Line Committee of 1885 in connection with the regulation of freeboards, and it has often been revived since. It was felt, however, that stability is so intimately related to stowage, and is so much in the hands of those in charge of the stowage, that it would be impossible to deal satisfactorily with it as a factor of depth of loading. Nothing can make a ship safe if her stability is not secured by proper stowage; but when vessels will obviously admit of being loaded with homogeneous cargoes, so as to have their stability dangerously reduced at sea, the official bodies who assign load-lines should look for proof that the danger is understood, and that measures will be taken in regulating the stowage to properly guard against it. I understand that this is the course taken by the Board of Trade and the authorities who assign freeboards when cases of such a nature come before them.

(To be continued.)

BALLOONS AND LIGHTNING.

DANGER FOR THE AERONAUT UP IN THE STORM CLOUDS.

DURING an inspection of troops by the King and Queen of Italy a short time ago a balloon ascension took place in Rome, and almost immediately afterward, when the balloon had reached a height of only about 1,000 feet, it was struck by lightning and after taking fire fell to the earth. The officer in charge, Capt. Ulivelli, an engineer officer and balloon expert, was so seriously injured by the fall of the basket that he died in a few hours.

This was the first time on record that a free balloon was struck by lightning. Captive balloons, on the other hand, have occasionally been known to serve as conductors between a cumulus cloud and the surface of the earth. This has happened several times in Rome.

For example, on November 17, 1891, a balloon sent up on Monte Mario, which had been partially hauled down on the sudden approach of a storm, was struck by lightning at a height of about 500 feet. The occupants, a captain of engineers, D'Amico, and a sergeant, escaped with comparatively slight injuries.

In the experimental trials of the German balloon sections balloons have often been struck by electrical discharges. A very exciting case of this kind occurred on May 22, 1902, at Hurlach, south of Kloster Ledfeld, in the Bavarian balloon troops.

First Lieut. Hiler, in charge of a balloon, found himself at about 6 P. M. at a height of about 2,000 feet, when a heavy black cloud appeared on the horizon, the approach of which caused the men at the telephone and the capstan to experience electric shocks. The officer in charge decided to bring the balloon down to the ground, but it was too late.

In the midst of the preparations to effect its descent a short, sharp thunderclap was heard and one of the horses of the balloon wagon fell over. The lightning had struck the balloon and set the cover on fire. In a minute the burning material fell to the ground, Lieut. Hiller in the burning mass.

The men came to his assistance so quickly that he suffered no injury from the fire, but his left leg and his right ankle were broken and he suffered a heavy concussion. After a long siege in the hospital he recovered. Three of the men standing below were also struck, and had marks on their breasts or the soles of their feet similar to the effects of small caliber bullets. They recovered.

These accidents have suggested the necessity for protecting captive balloons with special lightning conductors, connecting the iron parts with the cable and leading to earth from the capstan.

It has happened that even in fair weather a flash of lightning has been discharged from a passing heavy cloud. As a rule ascensions are not made in threatening weather, and this matter would have no general interest if it were not for the fact that captive balloons now form part of nearly all expositions of public outdoor entertainments and opportunity is generally given to make ascensions.

On these occasions, owing to the lack of proper precautions, accidents often occur. The principal societies which take an interest in and encourage this form of sport take precautions to avoid accidents, but irresponsible persons having balloons in charge are very apt to neglect them.

The question of the danger from lightning experienced by a free balloon has become very serious, owing to the great number of ascensions made nowadays, a number which is steadily increasing year by year.

The earliest record of an aeronaut's experience in a thunderstorm is that of the French scientist Testu Brissy. On May 11, 1786, while studying the electrical condition of the atmosphere, this experimenter made an eleven-hour night journey and remained for three hours in thunder clouds conducting his observations. He noticed several times on the iron points of the basket the well-known phenomenon of St. Elmo's fire.

John Wise, the noted American balloonist, gives an exciting description of his experiences in a storm during an ascent made on June 17, 1843. The balloon, as it came under a black cloud, began to rotate and to ascend rapidly. On entering the cloud Wise experienced a sensation of suffocating and had repeated attacks of vomiting.

In consequence of the great cold the ropes were covered with ice and snow fell. The balloon was whirled about and rose rapidly, roaring noises like those of a cataract resounding in the air. The balloon was sent alternately up and down several times with great rapidity. After about twenty minutes it was finally thrown out of the cloud.

Capt. Hildebrandt, of the German army, had a similar experience when he made an ascent on June 7, 1902, with the director of the photographic laboratory of the technical high school of Charlottenburg, Prof. Miethe. At 5:30 P. M., near Falkenberg, the balloon had the towline out, but to avoid injuring the cultivated fields a landing was not effected. The balloon soon reached Nieder-Finow, and then the forest at Liepe, but no good landing place was found.

Ballast was thrown out and the balloon rose a few hundred yards and entered an apparently harmless, low lying cloud. Suddenly the balloon began to rise very rapidly and a peculiar rushing noise became audible, as if there were a waterfall down below in the woods.

Hail fell into the basket from all sides. Three times the balloon was hurled rapidly from a height of about 400 yards to 2,400 yards and down again. The tow line stood out straight, nearly on a level with the basket, and the latter was thrown about so violently that the inmates had to hold on with both hands. The storm forced the gas out of the ventilator at a rapid rate, and opening the ventilator had no effect.

Little lightning was noticed, but the thunder was continuous and loud. After about thirty minutes, judging from the barograph curves, the balloon left the region of the thundercloud and fell at a rate of about thirty-four and a half feet a second to the earth. It alighted in the top of an old beech tree and remained there. Prof. Miethe was let down by the rope and brought people from Liepe in a wagon, and with their assistance the balloon was lowered to the ground.

Balloons have often been in cumulus clouds heavily charged with electricity, and sparks have been noticed on the iron ring or the writing lever of the barograph, but no effect like a lightning stroke has ever been experienced in free balloons.

It is therefore a question whether a balloon which may suddenly find itself in a thundercloud can be struck by lightning. In general, it may be assumed that this is impossible, since the outer surface of the balloon always takes the electrical potential of the surrounding air, consequently a flash of lightning (the equalizing of the difference of potential between two masses) cannot occur.

On the other hand, it is not impossible that when a lightning flash takes place between a cloud and the earth it may set fire on the way to the gas escaping from a balloon between the two, but this effect is not probable.

But it has often occurred that a balloon rapidly changing its elevation, as is nearly always the case in making a landing, charged as it is with the positive electricity of the upper layers of the atmosphere, comes down to the negatively-charged earth surface and thus causes sparks to fly from the iron valve or ring, which set fire to escaping gas and cause an explosion.

In this way the balloon "Humboldt," of the Berlin Aeronautic Society, was burned on April 26, 1893, while making a landing, as the valve was pushed to the ground by the strong wind. In 1902 the new balloon "Pannewitz" of the Berlin society burned up in the same way while making a landing on the island of Zealand.

Such discharges can be prevented by coating the surface of the balloon with calcium chloride, thus making it a conductor, as suggested by Sigsfeld, or by connecting the iron parts of the balloon by wires, with a long wire hanging down, thus effecting slow discharge before the basket reaches the ground. These precautions are now well understood by the principal aeronautic societies and are always taken, so that under their supervision there is little or no danger to the aeronaut from this source.—N. Y. Sun.

Work is nearing completion on a remarkable reference system—a card index—intended entirely for the use of the blind. It is being made on the point system—that is, by denoting each letter with pricks in the cards placed in various positions. The index is in the rooms of the department for the blind of the New York Public Library, a branch situated at Amsterdam Avenue and Eighty-first Street. The cards are larger than those employed in the ordinary indices, and are placed upside down in the drawers. Blind readers run their fingers over the reverse sides to ascertain the name of the book which contains the subject in which they are interested. There are now more than three thousand volumes. A consignment of books in Russian has recently been received, and there is a small collection of works in Arabic expressed in the point system which has a prominent place in the catalogue. First an index according to authors was made, and now the subject index is under way. Heretofore the blind visitor to the library has been obliged to consult with the librarian and have parts of the catalogue read to him. Various references and cross references which make up the card index will require thousands of cards, and those that have been completed represent nearly two years of hard work.

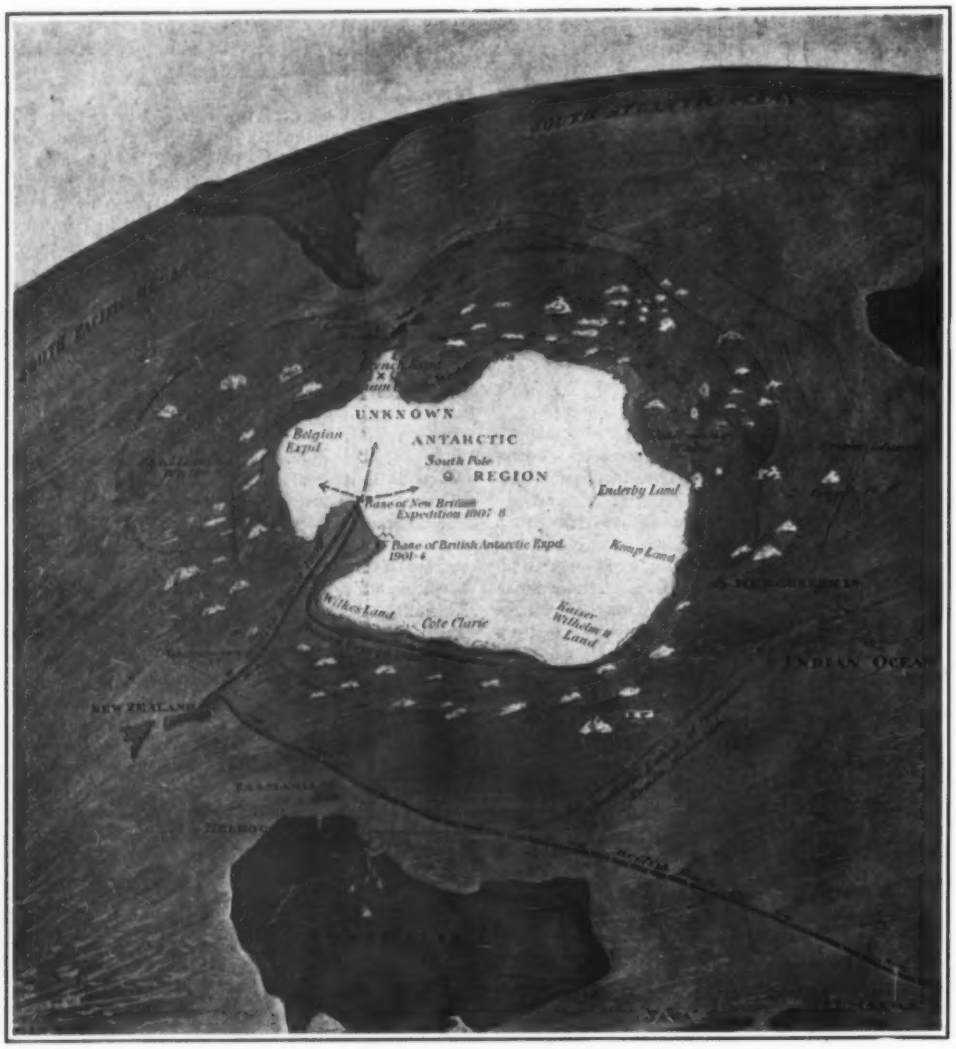
LIEUT. SHACKLETON.
Leader of the expedition.

LIEUT. SHACKLETON'S EXPEDITION TO THE ANTARCTIC AND ITS EQUIPMENT.

WINTER HEAD-GEAR.

A DETERMINED attempt to reach the South Pole is about to be made by Lieut. E. H. Shackleton, the British naval officer who as one of the members of the famous "Discovery" expedition reached the farthest point south ever recorded.

The expedition will sail, as so many expeditions have done, in an old boat—it might almost be called a "tub"—built for whaling or sealing in dangerous, ice packed seas. The "Endurance," as the boat will be rechristened, was built at St. John's, N. F., and has served a long apprenticeship to the seal fishery. She is said to have made many fortunes for her former owners, and to have the capture of 350,000 seals to her record. Battered and unattractive in appearance though she is, the boat has a magnificent hull, solidly built of oak. Where a big Atlantic liner would crumple in ice like a sheet of paper, the "Endurance" would resist and emerge unscathed.



WHERE THE NEW BRITISH ANTARCTIC EXPEDITION WILL ESTABLISH ITS BASE.

The new base will be established on King Edward's Land, and from this point sledge expeditions will be made in three different directions. One will be direct toward the South Pole, another one toward Graham Land, and a third in a S. E. direction. The positions of the coming Belgian and French expeditions are also shown by crosses. The expedition's vessel after leaving the base is to return to New Zealand and continue its magnetic survey in Australian and Indian waters. It will then return in 1909 for the land party, and the whole expedition will then, according to the present programme, return along the coast of the problematic Wilkes Land and so homeward along the coast as shown by the arrowed track.

In Lieut. Shackleton himself; Capt. England, his commander; and Mr. Dunlop, his chief engineer, the expedition possesses a trio of men of indomitable courage and stolid endurance, men who have thought out their plans to the smallest detail, and who are now going doggedly ahead to achieve success. Lieut. Shackleton himself conveys the impression, in conversation, that reaching the South Pole is a mere matter of course; and as he unfolds his plans, and his personality impresses one, a listener is almost impelled to second the belief. The lieutenant is a tall, broad-shouldered, squarely-built young man, with a frame that seems of iron, and with a firm "British bulldog" look that reads success in overcoming obstacles.

As on former Antarctic expeditions, a start will be made from New Zealand. The experience of former voyages goes to show that the pack ice is dispersed by the end of January, which is midsummer in the southern hemisphere; and the start will therefore be made from New Zealand at the end of the first week in the new year, 1908.

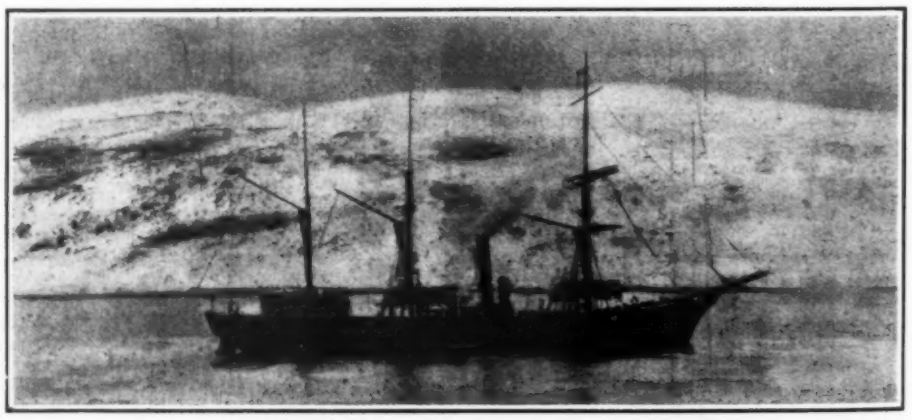
Lieut. Shackleton in an interview has expressed his belief that the South Pole is more attainable than the North, because in the south there are more extensive tracts of unbroken land. Toward the north there is much open water and ice of a rugged character, whereas around the South Pole there are immense plateaus of flat land.

King Edward VII. Land, at the eastern end of Ross's great ice barrier, has been selected as the base of operation in place of the headquarters of the "Discovery" expedition at the other end of the barrier. In many respects the change will be welcomed by geographers. McMurdo Strait, where the "Discovery" wintered, was the center of extensive explorations, lasting for a couple of years, while around King Edward VII. Land, which has merely been sighted as a strip of mountainous coast, there is practically a virgin field for exploration. The united expedition at the time of starting will probably number twenty-eight members, including a landing party of twelve. King Edward VII. Land it is hoped to reach by the first of February, and after landing the exploring party the "Endurance" will return to New Zealand. The expected nature of the land has led to the decision to use motor cars for transportation. Speaking of this choice in the Washington Post, Lieut. Shackleton says:

"Some persons seem to imagine that we have an idea of simply landing near the pole and then driving over in our motor. This is absurd. The motor is not intended for riding in at all. It is merely to haul provisions. We have especial sets of wheels adapted for certain qualities of ground; the material of which the motor is constructed has been especially hardened for low temperature. But we are not depending on our motor car. It will haul more provisions than will dogs or even ponies, and as we shall only use it over ground that we have first traveled and it will only go twenty-five miles a day or thereabout, stopping when the ponies stop, it is altogether a practical idea.

PONIES TO BE TAKEN BY THE EXPEDITION.

A very hardy type of pony will be carried by the expedition. They have been obtained in the coldest parts of Siberia.



THE "NIMROD," THE NEW ANTARCTIC EXPEDITION'S VESSEL.

As she will appear in antarctic trim with a high poop, square-rigged foremast, and crow's nest. She will carry 300 tons of coal for her engine. In her previous career she was a Newfoundland sealer.

LIEUT. SHACKLETON'S EXPEDITION TO THE ANTARCTIC.

"Another novelty of our expedition is the use of ponies instead of dogs. We have been criticised for this, but our idea is in my opinion a very good one. These Manchurian ponies have been thoroughly seasoned to stand very low temperatures in their own homes before we take them out, and there is no good reason to think that they will not prove very efficient.

"Of course, one thing may be said against ponies and in favor of dogs—dogs will eat dogs, but ponies won't eat ponies. Perhaps you don't catch the drift of my meaning? In an emergency, with provisions giving out and dogs dying, we can feed the live dogs on the dead ones. But with ponies we can't resort to this measure. From a practical point of view, however, the ponies will carry more weight, do more work and eat less food than any other animals for this purpose.

"With the exploring party will be landed on King Edward VII. Land the sections of a carefully planned living hut, twelve Siberian ponies, a team of twelve picked dogs from the far northwest of Canada and the specially constructed motor car which will form such a novel feature of the expedition.

"As for our food supply, we have studied this question down to the final analysis. Our foods are prepared with the utmost care. The tins they are packed in are of triple thickness and are doubly painted. Every particle of food packed is of the best. As I suffered terribly from scurvy on my first antarctic trip I know the value of this careful attention to the food supply. We are going practically without vegetables, as they do not keep, carrying only the best meats and other eatables.

"Work will at once be started in accordance with a definite programme. While the hut is being erected and the winter quarters otherwise put in order the closing days of the antarctic summer will be utilized for establishing a line of depots as far, it is hoped, as 150 geographical miles to the south.

"The part of King Edward VII. Land at which it is hoped to effect a landing is in about 77 degrees 30 minutes south latitude, or 750 geographical miles from the pole. During the winter the scientific studies for the pursuit of which the expedition will be fully equipped will absorb a large share of attention.

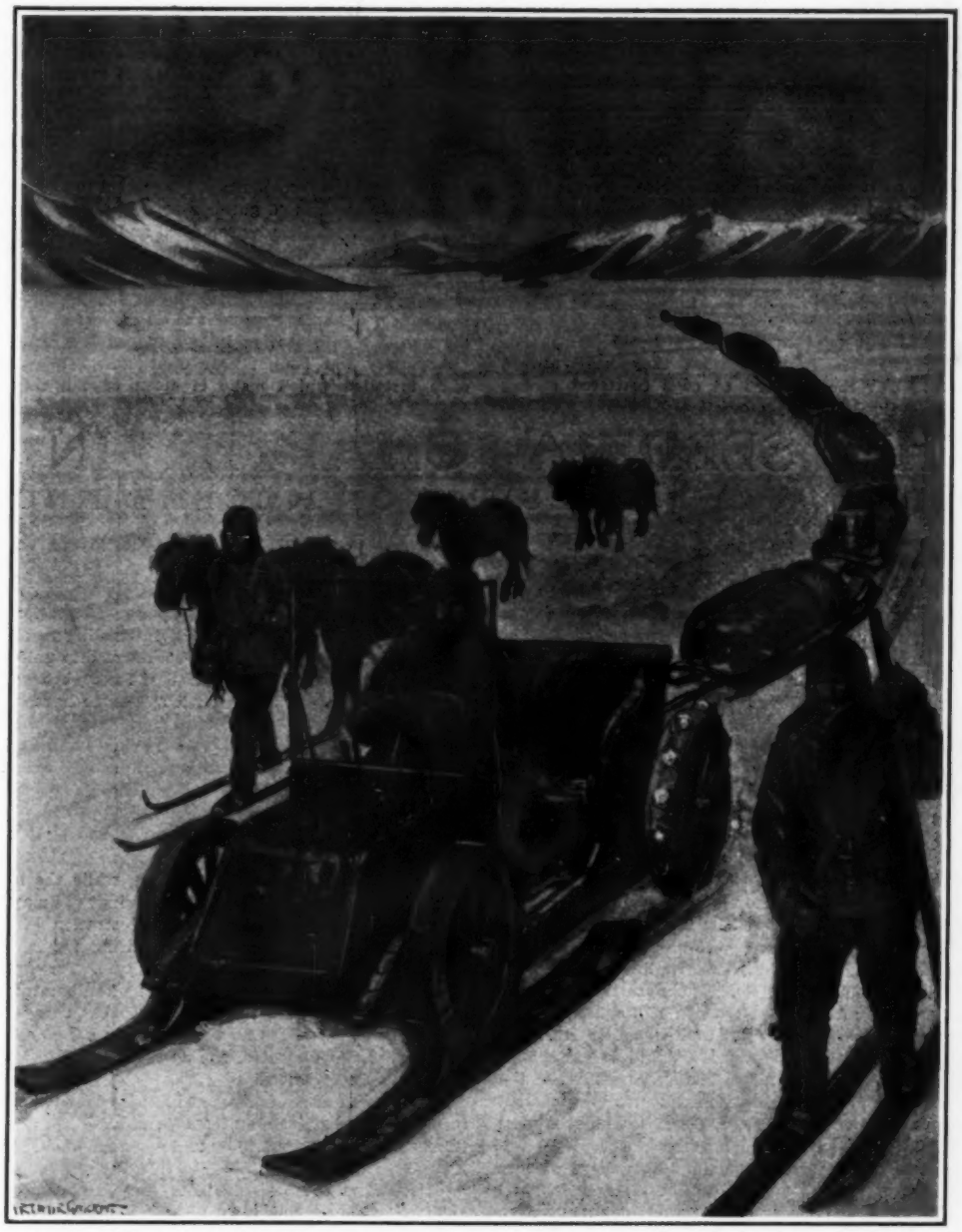
"With the return of spring efforts will be made to extend the line of depots another hundred geographical miles to the south—that is, to within 500 geographical *miles of the* Pole.

"As on the 'Discovery' expedition the party which will attempt to reach the South Pole will be limited to three members. With us we will take six of the Siberian ponies and the motor car. It will be driven by a spirit which will work satisfactorily in low temperatures. Great hopes are entertained of its value for traction purposes, but it is recognized that its employment is an experiment, and the chances of the expedition's success are far from being centered in any such novel means of locomotion.

"The use of Siberian ponies in the Antarctic is also in the nature of an experiment, but the hardiness and strength they have developed on the bitterly cold plains of eastern Siberia, where they are accustomed to live in the open all through the winter, justify the hope that the experiment will be attended with good results."

After leaving the exploring party on King Edward VII. Land the "Endurance" will devote much time during the next eight or nine months to a magnetic survey along the great trade routes between New Zealand and Australia and from Australia across the Indian Ocean.

A special compass platform will be erected at a height of between thirty and forty feet from the deck, and all iron fittings in its neighborhood will be replaced by brass fittings. Regular magnetic observations will be taken, and every 500 miles the ship is to be swung for deviation and variation.



LIEUT. SHACKLETON WILL PENETRATE BY THREE SLEDGE EXPEDITIONS, IN WHICH HE WILL BE AIDED BY THE USE OF A MOTOR CAR SPECIALLY BUILT FOR THE TASK. THE CAR IS PROVIDED WITH THREE DIFFERENT SETS OF WHEELS FOR USE ON SURFACES OF VARYING SOFTNESS. ITS EMPLOYMENT IS AN EXPERIMENT.

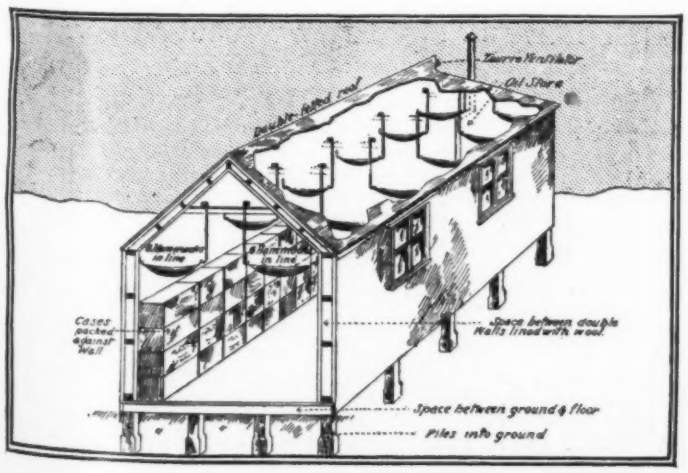
The return of the "Endurance" for the party has been fixed for about the end of January, 1909. Against any possible failure of the ship to keep the appointment the landing party will be doubly guarded. Not only are they taking out food supplies for two full years but they will be provided with a first-class lifeboat equipped with a motor engine.

Our illustrations are taken from the Sphere.

THE MODERN METHOD OF COLLECTING TURPENTINE.

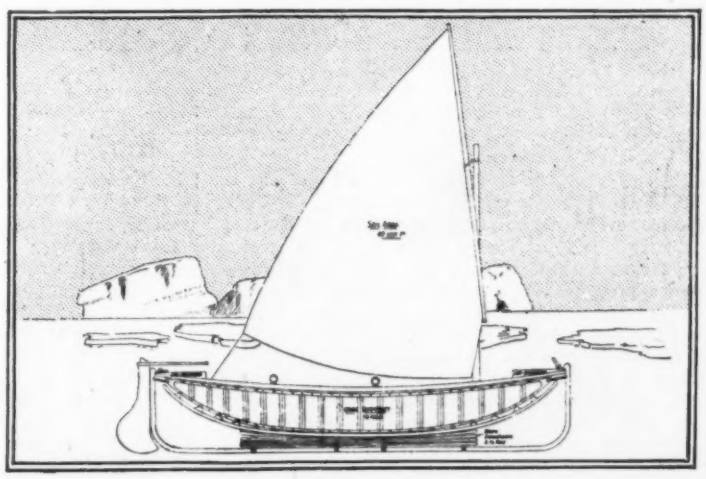
TWENTY million turpentine cups are used in the pine forests of the South to catch the flow of resin from the trees, and seven or eight million are added each year. These simple-looking cups, which are not unlike flower pots in size and shape, indicate a rapid and highly important change in the American method of gathering turpentine, due to the need of economy in using all forest products and to the application of science in an old-fashioned industry.

The old plan of cutting deep boxes in the trees, in which turpentine collected after running down the



THE LAND HUT OF THE EXPEDITION.

In which they will pass the long winter nights when the vessel has returned to New Zealand. It is specially constructed with double wool-packed walls for resisting the cold, is to be built on piles, and lined with cases of goods.



THE SPECIAL PORTABLE BOAT.

With detachable buoyancy apparatus to be fitted to the sides of the boat. It will be carried on the exploring journeys in case water is met with. In that event the party will be able to embark and navigate themselves over any intervening water.

LIEUT. SHACKLETON'S EXPEDITION TO THE ANTARCTIC.

scarified trunks, was universal until a few years ago. It was wasteful and destructive. Trees so mutilated were productive only about four years. They might continue to live, and they usually did not fall for years, but their value as turpentine producers was at an end and their value for lumber was seriously lessened.

The cup and gutter were devised to take the place of the old wasteful method. No box is needed, and the trunk is left strong and but little injured. Small galvanized iron gutters, attached in a simple yet secure manner to the tree, lead the turpentine from the scarified wood to the cup. The amount thus collected is greater than by the old method, it is of superior quality, and it commands a higher price. Further than this, the tree thus operated upon is productive about eight years, instead of four as under the old method, and produces more each year. In other words, one tree during its productive period gives more than the former yield of two.

The cup and gutter method did not go into general use at once. Nor is it generally used yet. The majority of operators cling to what they have always known. But the millions of cups scattered among the pine forests from South Carolina to Louisiana are proof that the four or five years since the new method was introduced have made a great change in an important industry.

The world depends largely on southern pine forests for naval stores. About half the product is exported. It is worth many millions annually. Turpentine supplies an enormous trade. America can hold this trade, but if it is to do so the valuable southern pine must be cared for. It was this which led to investigations on the part of the Forest Service in the effort to economize in reaping the turpentine crop. Several turpentine operators were foresighted enough to welcome the work, and co-operation between these private interests and the government foresters led to the introduction of the cup and gutter system.

The cup encountered prejudice, and at first overcame it slowly. The inventor found it necessary, with his associates, to buy a pottery to make the cups. Potters would not undertake the work. The article was new, was not in demand, and no one cared to take the risk of manufacturing it.

A pottery was bought near Chattanooga, machines were installed which make eighteen cups a minute each, and the cost per cup has been reduced from 4 cents, the price when hand made, to 1 6-10 cents.

Manufacturing the cups was only part of the battle. Operators in the turpentine forests, at the outset, would not touch the article. Then, when a tract of pine was at length secured, a great deal of trouble was had in persuading the laborers to work with the new device.

The cups won the day. Laborers learned to like them, and operators took them up. The source of supply for naval stores, and for all other uses of turpentine and its products, both for this country and for others, is more secure. Pine forests will last longer, produce more turpentine and rosin, and the timber is better.

When trees are boxed, that is, cut deeply, they are weakened. Wind levels them, and they often decay before the arrival of the lumberman, who follows the turpentine operator. Fire attacks the notched trunks of standing trees, and large numbers are lost. The slight mutilation for the cups and gutters does not subject the trees to so great danger and the lumberman finds them little injured.—From a Bulletin issued by the U. S. Dept. of Agriculture.

THE SEED, A CHAPTER IN EVOLUTION.—II.*

A RESUMÉ OF RECENT KNOWLEDGE.

BY PROF. F. W. OLIVER, M.A., D.SC., F.R.S.

Concluded from Supplement No. 1649, page 95.

A PECULIAR and distinctive, though negative, feature common to the whole range of Palæozoic seeds that have become known to us is the lack of an embryo. Occasionally small-sized seeds are met with, as in *Lagenostoma Lomaxi*, and now and then immature-looking stages, of which the best example is Renault's Cordaitean ovule, so often figured in the books. But apart from such rarities the petrifactions agree in being at a stage which, in the light of recent Cycads, is to be interpreted as corresponding to the time of fertilization. The pollen chamber is charged with pollen grains, while in good examples the megaspore is filled with a prothallus which frequently shows indications of archegonia at its upper extremity. All these specimens will be dismissed by some as abortive, and any conclusions drawn from the negative character as invalid. Without ignoring this contingency, another view is, of course, possible. The normal fall of the seed may have followed pollination at a short interval, much as is reported for *Cycas* and *Ginkgo* to-day. The "resting period" in these seeds would then perhaps coincide with the maturation of the sperms, while the subsequent embryonic history might have been carried through without a pause. This view gains support from the filicinean relationship, for of course the fertilized egg of a fern continues its development without interruption. If the modification of the pteridophytic life history that culminated in these early seeds were directed, as seems probable, to insuring a greater certainty in bringing the gametes together under conditions favorable to their union, it would follow that the other great advantage arising from the seed habit was of later acquisition. In other words, the ordinary seed with resting embryo was evolved by stages. There is a great lacuna in our knowledge of the early adjustment of the embryo to intraseminal existence. While evidence of Palæozoic seeds with resting embryos is altogether wanting, we are confronted in the Mesozoic rocks with the Bennettiteæ, all of which possess a well-marked dicotyledonous embryo practically filling the seed cavity. It is mere conjecture to suggest that this change has been wrought in response to some climatic stimulus, though the marked xerophilous facies of many of the Mesozoic Cycadophyta seem quite consistent with such a view. Be that as it may, one cannot fail to recognize that the resting seed with an embryo marks a great advance on the Pteridosperm, an advance hardly less important to the welfare of the plant than was the earlier type of seed on the extended life history of the filicinean prototype.

This stage of the seed-history would be of exceptional interest if we could hope to recover any morsels of direct evidence. As yet we remain in the dark as to the morphological nature of the embryonic organs, how far we are dealing with new structures produced from a protocorm, as Prof. Bayley Balfour has suggested;† how far they represent the old filicinean organs adjusted to intraseminal life. What chance there may be of the solution of this difficult problem by the application of other methods may emerge perhaps from the discussion on the phylogenetic value of early seedling characters which is to be opened next Tuesday morning by my colleagues Mr. Tansley and Miss Thomas.

Reference has already been made to the view that the seed, as we find it in the majority of spermophytes with its resting embryo, shows definite adaptation to seasonal periodicity. It would be interesting to learn how far the seeds of plants long accustomed to uniform conditions, such as the rainy tropical forest, behave in this respect. The point does not appear to have been very fully investigated. Indeed there is a rich field for both observational and experimental work upon obscure seed problems awaiting any one who can devote continuous attention to the subject. Is there any solid foundation for the supposed "physiological dimorphism" among seeds according to which, as one reads in the older books, the earlier ripening seeds are adapted to an immediate germination, while the later ones are reserved for the following spring? It may be that we have here but one more illustration of the operation of temperature as the limiting factor, but in any case the matter wants clearing up. An experimental investigation of the relations of "albuminous" and "exalbuminous" seeds would probably repay the trouble involved. Does any condition or set of conditions under the control of the operator exert an influence in this connection?

The mention of the early germination of seeds brings to mind the most striking instance of all—that of the tropical mangrove, in which, as is so well known, the seed germinates on the tree, so that the young plant is extruded, and in some instances falls, from the parent free of its envelopes.

Our interest in this type of vegetation has been revived through the researches of Mr. H. B. Guppy incorporated in his recent contribution on "Plant Dispersal in the Pacific." This volume, perhaps the most important contribution to the biology of tropical plants that has appeared since the death of the lamented Schimper, is distinguished alike for its wealth of new observations and its engaging freshness of treatment. There is one suggestion of Mr. Guppy's concerning the vivipary of mangroves which may occupy our attention for a few moments.

As a result of his studies in the Pacific and elsewhere Mr. Guppy has arrived at the conclusion that the mangrove type of vegetation is a very ancient one, dating back to the times when climate was more uniform and moist than we know it to-day. The viviparous habit he conjectures to have been once very general, while to-day this primitive condition is making its last stand along the tropical shores. Traces of vivipary still occur among inland plants, such as *Crinum*, while in other cases it reappears intermittently under conditions not fully ascertained. Mr. Guppy supposes the ordinary fruiting way of plants with caducous fruits or seeds, that germinate after an interval, to have arisen by a modification of the continuous viviparous method in the sense that the seed has come to fall earlier and earlier till the stage now characteristic of practically all Spermophytes has been reached.

Piecing the data together, this seems to be the position: The earliest known seeds appear to have remained on the plant just long enough to receive their pollen; but in time, it is reasonable to suppose, the advantage of remaining longer was realized, and the fall of the seed was postponed till fertilization was followed by the occupation of the seed cavity by an embryo. Here in seclusion the embryo could remain until germination was convenient. Starting at the other end, our modern seed, according to Mr. Guppy, has been evolved by the gradual retention of the viviparous embryo; or, to put it in another way, the detachment of the seed has been hastened so that it falls long before germination is due.

Well, these theories fail to meet in the middle, as they should if they are to present us with an epitome of the whole seed-history. Perhaps there were troublous times in that middle epoch, so that the continuity has become obscure! Or possibly another view may be admissible of the relation of vivipary to normal seed production. Most botanists, I take it, have been inclined to regard vivipary as the *dernier cri* in seed history, the ultimate stage in the way of possible reproductive advance in seed-bearing methods that the higher plants have yet attained. The mangrove process might even be conceived as the starting point, under certain contingencies, of a whole new race of plants with life histories complicated by fresh alternations—homologous alternations—far beyond any of which we have knowledge to-day!

Schimper and others who have given attention to the subject found no reason for regarding vivipary as other than an adaptation to special circumstances, an extreme condition that had arisen independently in several cycles of affinity. Before the contrary can be accepted a good deal of positive evidence will be needed, drawn from the non-mangrove representatives of groups in which vivipary occurs, to show that the relationship is other than has been generally supposed. Moreover, if the viviparous habit were formerly of wide occurrence some traces of it might reasonably be expected in the fossil record. So far as can be ascertained, such have not been forthcoming, nor can I hear of any record of recent mangroves being preserved in this way. Seeds and embryos appear to be so uniform on the whole that it is difficult to understand how they could have passed through a viviparous phase in the later stages of their evolution.

The viviparous Mangroves, on the other hand, are full of diversity in detail, and these differences would surely have left a permanent mark had the course pursued been in conformity with Mr. Guppy's very interesting suggestion. That there is a rich field awaiting detailed investigation in connection with the fascinating subjects opened up by Mr. Guppy will be admitted by most naturalists.

In glancing back at the early seed structures one is struck with the complexity of their organization as compared with the relative simplicity of modern seeds. The pollen chamber, the large elaborate integument, and the complicated vascular arrangements, so characteristic of the Pteridosperm seed, have for the most part pasesd away, giving place to much simpler structures. Occasional exceptions no doubt occur; the seeds of palms have remarkable integuments, while those of *Magnolia*, some Aroids, Sapotaceæ, etc., show an unusual development of vascular tissue. Most astonishing of all perhaps is the integumental tracheal sheath which closely invests the nucellus of *Cassytha*.* Though evidence of their precise function be lacking, the fact that many of these structures belong to the tropical forest makes closer knowledge desirable. For in these localities the conditions must have long been relatively stable; thus increasing the chance that the structures referred to still perform their pristine functions. These and other cases like them need elucidation, but to the broad statement that the seeds of recent Spermophytes are organized on simple lines there can be no question. This reduction in complex-

* Read before the Botanical Section of the British Association for the Advancement of Science.

† Presidential Address, Section K, Glasgow, 1901, p. 9.

* M. Mirande, "Le dévelop. et l'anat. d. Cassythacées," Ann. d. Sc. Nat., 9e sér. bot., tom. ii., 1905.

ity may be accounted for on two grounds. In the first place fertilization by motile sperms has been replaced by fertilization by pollen tuber. Instead of germs being discharged into an internal water chamber upon which the archegonia abutted, the male cells are carried through soft tissues to the egg in a plastic tube.

In other spheres the like befalls. If primitive man had occasion to journey from Baker Street to Waterloo, he penetrated the forest and then swam the river; to-day his descendants are projected from the one to the other with accuracy and dispatch in a subterranean passage.

Just at what stage the improvization of the pollen chamber gave place to the newer method we have no knowledge. Perhaps some information on this point may emerge from Dr. Wieland's exhaustive researches into the extensive Yale collections of American Cycadeoideas. For the Bennettiteæ already show a simplification of the seed in certain respects; though, owing to the late stages of development usually found in European examples, this point could be cleared up.

The other cause that must have played a prominent part in the simplification of the seed was the association with it of other structures which relieved it of a part of the original load of duties that fell to its lot. The dense heads of *Bennettites* show us this, and the same may be said of most Coniferous strobili. But the Angiospermic ovary provides the best example of a special organ inclosing the seed or ovule, affording it protection during the immature stages and also collecting the pollen. The steps by which this came about remain hidden, and any discussion of the matter is of course premature. The carpels may have been derived from reduced sporophyls or from portions of sporophyls that were more closely associated with the seeds. The cupule of *Lyginodendron* is an organ rather suggestive in this connection. One is tempted to compare it with a rudimentary ovary, playing the serviceable part of a moist air chamber for the seed during the earlier stages of its development.

However, the origin of the fruit and of the flower, with all its manifold organs, must be left to the future: they form no part of our theme. Some day a happy discovery will yield a clue, and the reproach that we are in entire ignorance of the affinities of the dominant phylum will be removed.

The history of the seed, as I read it from the imperfect and fragmentary data that are available, has been a series of advances spread over long geological periods. The possibilities of the seed habit were realized only bit by bit, and the high efficiency of the modern seed depends in large degree upon the close association of other structures which co-operate in its functions. No doubt the first step, the retention of the megaspore, was the most important of all; though, that this might be effective, some contrivance for the capture of the pollen grains must have accompanied it. Later steps in the process of seed evolution would include the adjustment of an intraseminal embryonic stage, and in time the substitution of the pollen tube for the liberation of sperms.

Now assuming, as I think we are entitled to assume, that seeds have come into existence along some such lines as those thus crudely blocked out, there is a great difficulty in conceiving the process other than discontinuous. Every one of the stages emphasized involves the conception of something more abrupt than mere gradual variation. And there is, of course, the old difficulty confronting us as to how the organ or mechanism came to be preserved at its inception. All these difficulties vanish when it is recognized that effective variation is of the discontinuous order, and that the successive changes involved may be considerable enough to be designated jumps. Happily such views, based upon experimental results, have been formulated by De Vries in his Mutation Theory. That theory is so well known to botanists in this country that any exposition here is quite superfluous. The least thing that can be said in its support is that it is perfectly tenable. But we may go much further than that. Apart from the Theory of Natural Selection, no modern hypothesis of evolution has been so helpful or so likely to stimulate further work. The results of continued investigations in this field, now so actively pursued, will be awaited by all biologists with a keen and sympathetic expectancy. Not the least of the advantages that follow in the wake of the Mutation Theory is the shortening of the time required for the evolutionary process. As the physicist imposes a time limit to the period during which life has been possible on the earth, a working theory that reconciles the demands of the biologist with the physical limitations is decidedly reassuring. In this connection it is very interesting to note that Monsieur Grand'Eury, one of the most active and distinguished workers in the field of palæobotany, should have found data supporting the view of mutation.* In tracing the passage of fossil plants through great thicknesses of rock he has been impressed on the one hand with the high degree of permanence of certain forms, and on the other with the suddenness, when the moment came, with which one species passes into another.

The collection of data of this kind from our own Coal Measures appears to me a very pressing necessity in view of the rapidity with which the coal fields are being exhausted. Indeed, the present is an unique opportunity which can never recur, and the chance of systematically utilizing it is slipping away. Whatever view one may hold as to the expediency of making exhaustive collections of the recent flora, there can be no two opinions of our manifest duty to "make hay while the sun shines" in the matter of coal fossils. Regarded as systematically arranged collections showing how the plants occur in definite localities, the contents of most of our museums, as I am assured by competent authorities, are practically worthless. That innumerable specimens of the greatest value are preserved in museums may be readily conceded; but my point is that these collections have been made without system, and that details of precise locality and horizon are frequently wanting. All this has to be done over again, and I believe local societies working in touch with a central organization could do a memorable service which would earn them the gratitude of future generations and at the same time provide a fresh outlet to their energies.

To us the coal industry, with its vast resources, is a convenient mechanism for making fossil plants accessible. The colliery proprietor may be relied on to afford all reasonable facilities for the acquisition of select examples from these superabundant and embarrassing waste products. Should he incline to go further and contribute toward the modest funds necessary to carry out the undertaking worthily, he would increase the debt which science owes to industry. The thousandth part of the revenue arising from the export tax on coal would amply suffice for the purpose. Indeed, I can think of no more appropriate way of celebrating the abolition of that burdensome impost.

If I have dwelt to-day on the seed to the exclusion of other features, it is because I am convinced of its supreme importance. The evolution of the seed must have been one of the most pregnant new departures ever inaugurated by plants. The revelations of the last few years afford us, it is true, but the merest glimpse of the first stage reached, the rise of the Pteridosperms. The conquest of the world must have been slow then as it is now. The great forests of Lepidodendrons and Calamites were not reduced to mere Lycopodiums and Equisetums all at once. In this prolonged struggle, even if the Lycopods never produced a race to share the spoils, as some suppose, there is the evidence of *Lepidocarpon* that their reproductive methods underwent a certain if ineffectual modification in the same direction as their eventual supplanters. Probably the seed plants asserted themselves wherever physical changes overwhelmed old habitats. The rise and fall of the land, so great a feature in Carboniferous times, would favor the younger group. For as new ground became available for colonization there would be opportunity of competing on at least equal terms with the effete types that cumbered the forest land. Nor should we forget that the seeds were well equipped with dispersal mechanisms almost as varied as they are to-day.

A somewhat similar struggle is now in progress between the Angiosperms and Gymnosperms, but so slowly that we hardly notice it. A future age may have to be content to know its Gymnosperms from dwarf forms like those which the Japanese are so fond of producing in their pot cultivations. But perhaps all calculations will be upset by the more effective intervention of the human race. On present indications the vegetation of the future should consist of cultivated crops and the weeds that accompany them; that is, unless the chemist comes to our aid and solves the problem on other lines.

* Grand'Eury, Comptes Rendus, tom. cxlii. p. 25.

IMPORTS OF UNITED STATES, BY PRINCIPAL SOURCES, 1907.

ALL the world, or at least all the grand divisions of the world, have profited by the large increase of importation during the fiscal year just ended. This increase in importations, as already announced by the Bureau of Statistics of the Department of Commerce and Labor, amounts to over 200 million dollars as compared with the immediately preceding year. Of this increase of over 200 million dollars, about 115 millions occurred in the imports from Europe, 33 millions in imports from Asia, 25 millions in the imports from North America, about 20 millions in the imports from South America, nearly 10 millions in the imports from Africa, and about 5 millions in the imports from Oceania.

The United Kingdom, Germany, France, Brazil, Japan, British India, Cuba, Italy, Egypt, and China are the chief beneficiaries in this increase in foreign purchases by the people of the United States.

The largest increase in the imports from any single country is from the United Kingdom, from which the imports increased about 37 million dollars over the immediately preceding year, the fiscal year 1906. This increase in the imports from the United Kingdom occurs chiefly in pig iron, pig tin, pig copper, tin plate, laces, and miscellaneous manufactures. Pig iron alone shows an increase in the eleven months ending May of nearly 7 million dollars from the United Kingdom alone, pig tin an increase of nearly 4 million dollars, pig copper an increase of 3.5 millions, while cotton cloths, cotton laces, silk, crude India rubber, and manufactures of various sorts, as well as many other less important articles, show a considerable increase from the United Kingdom.

From Germany the imports show an increase of about 26 millions. This increase occurs chiefly in beet sugar, chemicals, kid gloves, silks, knit goods, and paper manufactures, the largest single increase being in sugar, which alone shows an increase in the eleven months ending with May of nearly 6 million dollars compared with the immediately preceding year. From France the imports show an increase of about 21 millions, the gain occurring chiefly in silks, laces, diamonds, kid gloves, and other manufactured articles. From Italy the imports show an increase of about 10 million dollars, the gain occurring chiefly in raw silk, of which the imports from Italy in the eleven months ending with May were about 3 million dollars in excess of those of the corresponding months of the preceding year. Lemons also show an increase of over a million dollars, while other fruits, cheese, olive oil, and miscellaneous merchandise show also an increase. From Netherlands the imports show an increase of about 6 million dollars, the gain occurring chiefly in diamonds and tobacco from her East Indian possessions.

From Canada the imports show an increase of about 6 million dollars, the gain occurring chiefly in lumber and copper. From Mexico there is an increase of about 5 million dollars, this gain occurring chiefly in rubber, copper, and hides. From Cuba the imports show a gain of about 10 million dollars, the increase occurring chiefly in sugar, also in bananas, tobacco, cigars, and iron ore. From Brazil the increase is about 17 million dollars, occurring chiefly in coffee, cacao, and rubber, the increase in coffee amounting to over 6 million dollars, in cacao to about 1.5 million dollars, and in India rubber to about 8 million dollars.

From China the increase in imports is about 7 million dollars, occurring chiefly in silk and wool. From Japan the increase amounts to about 15 million dollars, the gain occurring largely in silk, of which the imports in the eleven months ending May were about 12 million dollars in excess of those of the corresponding months of the preceding year. From British India the importations show an increase of about 12 million dollars, this gain occurring chiefly in burlaps, jute bags, and manufactured jute. From Australia and New Zealand there is a gain of about 5 million dollars, this increase occurring chiefly in wool. From Egypt the imports show a gain of about 6 million dollars, the gain occurring chiefly in raw cotton.

The increase in importations is divided about equally between dutiable and non-dutiable merchandise. Dutiable merchandise shows an increase of a little more than 100 million dollars, that coming in free of duty a gain of about 100 millions. Of the great groups, food stuffs in a crude condition show a gain of about 15 millions, food stuffs partly or wholly manufactured a gain of about 15 millions, manufactures ready for consumption a gain of about 55 millions, manufactures for further use in manufacturing a gain of about 57 millions, and crude materials for use in manufacturing an increase of about 66 millions.

According to a recent report which has appeared in Switzerland upon the construction of the Bernese Alps railroad and the Lötschberg tunnel, the latter is to be completed within four and a half years after the first boring, the contract price to be $5,540,000. It is to be finished by September 1, 1911. The tunnel will have a total length of 8.5 miles, and will run in a straight line. On the southern side the track will come out in a curve. A single track will be laid in the tunnel. The installation for the north end will be placed at the foot of the Schafberg and for the south end at Goppenstein. Current for operating the electric motors and for the lighting of the tunnel during the work will be obtained from the two hydraulic plants of Kander and Hageneck, on the north side, and from a plant at Lonza, at the south end of the tunnel. The triangulation for the tunnel was finished on the 29th of September, 1906, and as the results are very nearly concordant, they will be somewhat rectified during the summer of 1907. For the altitudes, the data are already given by the government surveys, and the Federal Topographic Bureau recently proceeded to make some additional surveys upon the levels in this locality. As to the railroad line, it will start from the town of Frutigen, which is the terminus of a line coming from Spiez and lying upon Lake Thun, and after passing along the Kander Valley will enter the Lötschberg tunnel. Coming out of the tunnel, it proceeds along the side of the mountain, and then passes along the Rhone Valley, reaching Brigue, the terminus of the line. Here it makes connection with the Simplon Railroad.

ESTIMATING HEIGHTS AND DISTANCES.

SOME ROUGH AND READY METHODS.

BY JAMES ASHER.

In the following paragraphs several rough and ready methods of estimating the heights and distances of various objects are shown, and accompanied by practical problems. Many of these methods give surprisingly accurate results.

MEASUREMENT OF HEIGHT.

1. To find the height of a tree, set a stake in the

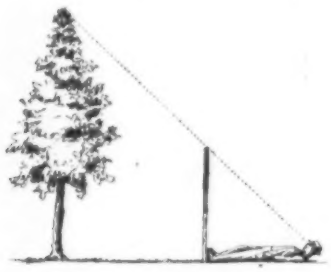


FIG. 1.—HEIGHT OF TREE EQUALS ITS DISTANCE FROM THE EYE.

ground at a distance from the tree which seems nearly equal to the tree's height. The stake must be vertical, and its upper end should be on a level with the eye. The observer should then lie on his back on the ground, with his heels just touching the stake and pointing toward the tree. If he can just see the top of the tree, the distance from his eyes to the foot of the tree is equal to the height which is sought.

2. Heights of objects may be measured by the aid of two parallel upright rods fixed to a wooden base (see Fig. 2). One rod may be 4 and the other 5 feet high, in which case they should be a foot apart. Move this instrument back and forth, keeping the base on level ground, and aim from the top of the shorter rod over the top of the longer one. When the line of sight meets the top of the tree, the eye is as far from the tree as the top of the tree is above the level with the upper end of the shorter rod. Add 4 to the distance from the shorter rod to the tree to find the height. This simple instrument is of use to lumbermen and others.

3. By means of the image of an object reflected in a vessel of water, its height can be readily calculated. For example, in Fig. 3, the height a of the eye above the level of the water is to the distance b between the point on the water where the top of the tower appears and a vertical line drawn from the observer's eye, as the height a' of the tower is to the distance b' of the tower from the point where the reflected image appears ($a : b :: a' : b'$). Example: A man sees the image of the top of a tower in a vessel of water whose

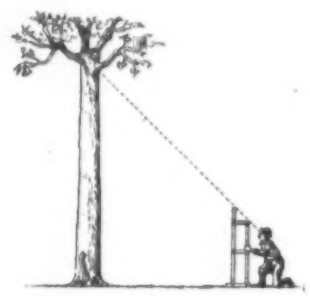


FIG. 2.—MEASURING WITH THE AID OF TWO PARALLEL RODS.

surface is a foot above the ground. The height of the eye above the water is 4 feet. The distance of the point where the image appears from a vertical through the eye is 7 feet, and the distance of the image from the tower is 140 feet. What is the height of the tower? Answer: $4 : 7 :: 80 : 140$. The top of the tower is 80 feet above the water, or 81 feet above the ground.

4. The heights of objects can be found in the following manner from the lengths of their shadows: Set a stake vertically in the ground, and wait until the length of the shadow of the stake is equal to the height. At the same time mark a spot on the ground where the shadow falls of the top of the tree, steeple or other object to be measured. The length of the shadow is then equal to the height of that object. There are parts of the world and seasons of the year wherein this method cannot be used. In all places having a latitude higher than 68½ degrees, either north or south, the shadow of the object is always longer than the height. The foregoing wonderfully simple method was used by Thales, one of the seven wise men of Greece, 2,500 years ago, in measuring the height of Cheops, the greatest pyramid of Egypt.

5. In a similar way, the height of a steeple or other object may be found by proportion (Fig. 4, $a : b :: a' : b'$). Suppose that the length of the shadow of the steeple is 120 feet, the length of the staff's shadow is 6 feet, while the height of the staff is 5 feet. The height of the staff is to the length of the staff's shadow as the height of the steeple is to the shadow of the steeple, that is, $5 : 6$ as $x : 120$, hence the height of the steeple is 100 feet.

Mr. W. D. Graves, of Brown Valley, Minn., suggests the following method, which is practically the same as the one just described. From the base of the object, stretch a tape line, as nearly level as possible, to the end of the shadow. Now take a square, preferably with one arm a foot long, and with this arm upright lay the other along the tape with the "heel" of the square at the end of the shadow. Note the length measured by the tape line and the length of the shadow of the upright arm on the horizontal arm of the square. As the shadow of the rule is to the length of the rule, so is the shadow of the object to its height. If the shadow of the foot rule is 7½ inches, and the shadow of the object is 38 feet, or 456 inches, then we have $456 \div 7\frac{1}{2} = 60\ 4\text{-}5$ feet; for 7½ inches of shadow is equal to one foot of substance.

6. The heights of mountains can be found by allowing 600 feet for each degree of difference between the boiling points of water at the base and the summit of

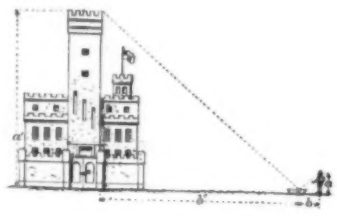


FIG. 3.—MEASUREMENT BY REFLECTION.

the mountain. Thus, suppose that water boils at 212 degrees at the base. The difference between the two temperatures is 26. Hence the height of that mountain is 26 x 600, or 15,600 feet.

7. Heights of moderate elevations can be found by means of a barometer. One-tenth of an inch corresponds to 90 feet of ascent. Example: The height of a barometer at the ground is 29.34 inches, while it is 29.14 at the top of the tower at the same time. What is the height of the tower? Solution: The difference between 29.34 and 29.14 is 0.20, or 2-10 of an inch. Now, since 1-10 of an inch corresponds to 90 feet, 2-10 will correspond to 180 feet, which is the height of the tower.

MEASUREMENT OF DISTANCES.

1. The distance of an object can be found by observing the time in seconds required by sound to traverse the space intervening between the object and the observer. The velocity of sound at 32 deg. F. is 1,090 feet a second. It is one foot a second more than this for each degree above and one foot a second less for each degree below 32 deg. For example, a person sees steam rise from the whistle of a distant locomotive; he hears the sound 15 seconds later. The temperature of the air is 67 deg. What is the distance of the locomotive from the observer? Solution: The temperature is 35 deg. above the freezing point, consequently the velocity of sound is 1,125 feet a second. The time required by the sound wave in passing from the locomotive to the observer is 15 seconds, therefore the distance is 15

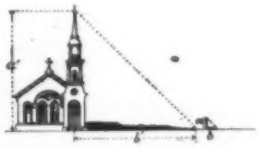


FIG. 4.—THE LENGTH OF SHADOW AS A GAGE OF HEIGHT.

times 1,125 feet, or 3 miles and 1,035 feet. The distance of a cannon or a flash of lightning can be calculated in the same manner.

2. The breadth of a river can be roughly measured without instruments in the manner illustrated in Fig. 5. Stand at the edge of the river, and pull down the visor or peak of your cap until the lowest part just intercepts your view of the water's edge on the opposite side of the river. Next turn slowly about, keeping the head steady, until you face either upstream or downstream on your own side of the river. Observe the spot where the line of sight past the lower edge of the cap peak meets the shore. The distance from the spot on which you stand to this point is equal to the river's

FIG. 5.—SIMPLE METHOD OF ESTIMATING DISTANCE.

width. The writer once measured the width of the Niagara River between Fort Erie and Buffalo in this manner. The breadth of the river is 700 yards.

3. We can also measure the distance of an object in the following manner, as illustrated in Fig. 6: Measure a base line of convenient length, then stretch a string from each end of this line directly toward the distant object. From the farther end of one of these strings measure the distance between the two, being careful to measure parallel to the base line. Multiply the length of the measured string by the length of the base line, then divide the product by the difference between the length of the base line and the distance between the strings at the farther end of the measured string. The result will be the distance of the object from the point of intersection of the base line and the measured string. Example: The base line is 217 feet long, the length of one string is 197 feet, the distance between the two strings at the end of the measured string is 184 feet. What is the distance of the object from the base line where it intersects the measured string? Solution: $33 : 197 :: 217 : x$. Multiplying 217 by 197, and dividing the product by 33, which is the difference between 217 and 184, we obtain for our answer 1,295 feet as the measure of the distance sought.

AUDIBILITY OF THE AURORA.

By W. F. King.

Doubt has been cast upon the reality of the aurora's audibility from the fact that apparently the sound has never been heard by any of the scientific Arctic explorers, though they have listened for it. The evi-

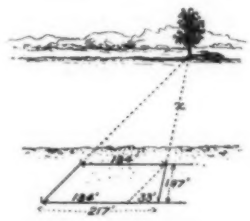


FIG. 6.—A WELL-KNOWN METHOD OF MEASURING DISTANCE.

dence of those who claim to have heard it is commonly, in scientific writings, turned by the supposition that the sounds are due, not to the auroral movement, but to the cracking of ice, the driving of snow before the wind, etc.

In this connection may be cited a piece of evidence which, though in print for nearly twenty years, has not yet found its way into the literature of the subject.

Mr. William Ogilvie, the well-known surveyor and explorer of Yukon Territory, in a report forming Part 8 of the Report of the Department of the Interior for the year 1889, says:

"As to the aurora making an audible sound, although I often listened when there was a very brilliant display, and despite the profound stillness which is favorable to hearing the sound, if any sound occurs, I cannot say that I ever even fancied I heard anything. I have often met people who said they could hear a slight rustling sound whenever the aurora made a sudden rush. One man, a member of my party in

1882, was so positive of this that, on the 18th of November, when there was an unusually brilliant and extensive display, I took him beyond all noise of the camp, blindfolded him, and told him to let me know when he heard anything, while I watched the play of the streamers. At nearly every brilliant rush of the auroral light, he exclaimed: 'Don't you hear it?' All the time I was unconscious of any sensation of sound."

The simple test applied disposes of two explanations which may suggest themselves in ordinary cases—conscious imposture, and self-deceit from the impression on the mind produced by the seemingly violent movements of the streamers. That the sensation of sound coincided with the rush of the streamers shows that what was heard was not the wind, unless this wind was a phenomenon of the aurora. There remains the curious fact that the sound was not heard by both. Whether this was due to difference as to keenness of hearing, or to some physiological effect to which different persons are not equally sensitive, does not appear.

CLOCKS—ANCIENT AND MODERN.*

AN HISTORICAL REVIEW OF HOROLOGY.

BY W. S. EICHELBERGER.

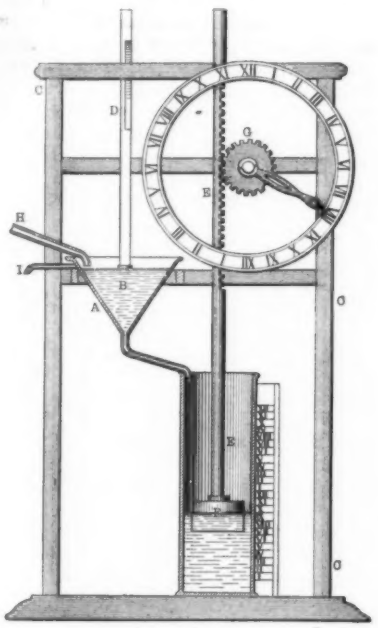
IN Nepal, a small independent state situated on the northeastern frontier of Hindostan, there is still practised what is one of the crudest and probably earliest methods of measuring time. A copper vessel with a small hole in the bottom floats on water, sinks and fills sixty times a day. Each time it fills a gong, or ghari, is struck, in progressive numbers from dawn to noon; after noon the first gong struck indicates the number of gharis which remain of the day until sunset. Day is considered to begin when the tiles of a house can be counted or when the hairs on the back of a man's hand can be discerned against the sky. The day is divided into 60 gharis of 24 minutes each, each ghari into 60 palas, and each pala into 60 bipalas.

Leaving India for Sumatra, and stepping aboard a Malay proa, we would there find, floating in a bucket of water, a cocoanut shell having a small perforation, through which the water by slow degrees finds its way into the interior. When the shell fills and sinks, the man on watch calls the time and sets it afloat again.

The gradual development through untold ages of the floating copper vessel has given us our finest astronomical clocks of to-day, and similarly the floating cocoanut shell may be considered the simplest form of a marine chronometer.

If now we visit the Chinese empire, we find in use there also the water clock, but instead of the water flowing into a vessel through a small hole in the bottom, it flows out of the hole. In attempting to calibrate such a vessel so that any given portion of the whole time required to empty it might be determined, it is at once noticed that when the vessel is nearly full, the water flows out more rapidly than when it is nearly empty. The difficulty here presented is most easily overcome by keeping the vessel filled with water, when the flow will be uniform, and catching the discharged water in a cylindrical vessel in which the surface of the water will rise equal distances in equal times. Chinese writers ascribe the invention of this instrument, called a clepsydra, to Hwang-ti, who lived more than twenty-five centuries before our era. About fourteen centuries later Duke Chau introduced a float upon the surface of the water in the final cylinder, by means of which an indicator was made to travel over an adjacent scale as the water rose in the cylinder, thus allowing the indications of the instrument to be perceived at a greater distance.

These instruments that have just been described may be called artificial time-keepers, and are used primarily to subdivide the day, while the sun-dial of equal antiquity with the others may be called a natural timekeeper, as it gives a means of determining day after day a particular time of day, such as apparent noon.



FIGS. 1 AND 2.—EARLY FORMS OF CLEPSYDRA.

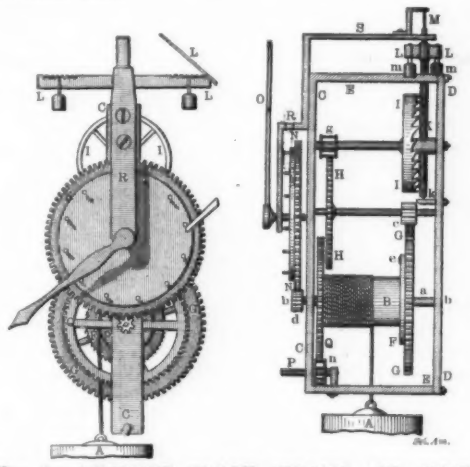


FIG. 3.—ANCIENT CLOCK (FRONT AND SIDE VIEWS) OF HENRY DE VICK.

The earliest mention of a sun-dial is found in Isaiah xxxviii, 8, in connection with the promise of the Lord to add fifteen years to the life of Hezekiah, who lived about 2,600 years ago: "And this shall be a sign unto thee from the Lord, that the Lord will do this thing that he hath spoken; behold, I will bring again the shadow of the degrees, which is gone down in the sun-dial of Ahaz, ten degrees backward. So the sun returned ten degrees, by which degrees it was gone down."

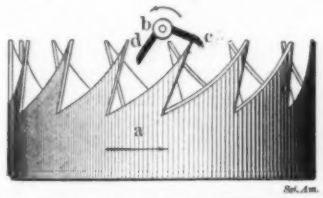


FIG. 4.—DE VICK'S ESCAPEMENT WHEEL.

Of the nature of this sun-dial nothing is said, nor is there found any description of such an instrument until 350 years later, when we find the sun-dial of the Chaldean priest Berosus, who lived in the time of Alexander the Great and his immediate successors.

This consisted of a hollow hemisphere placed with its rim perfectly horizontal, and having a bead fixed at its center. So long as the sun remained above the horizon the shadow of the bead would fall on the inside of the hemisphere, and the path of the shadow during the day would be approximately a circular arc. This arc, divided into twelve equal parts, determined twelve equal intervals of time for that day. Now supposing this were done at the time of the solstices and equinoxes, and on as many intermediate days as might be considered sufficient, and then curve lines drawn through the corresponding points of division of the different arcs, the shadow of the bead falling on one of these curve lines would mark a division of time for that day, and thus we should have a sun-dial which would divide each period of daylight into twelve equal parts. These equal parts were called *temporary hours;* and since the duration of daylight varies from day to day, the temporary hours of one day would differ in length from those of another. Dials of this form were still used by the Arabians a thousand years ago, and about 1750 four such were found in Italy.

The introduction of the sun-dial into Greece is generally fixed by historians in the latter part of the sixth century B. C. At that time the instrument seems to have been a very crude one, consisting merely of a pillar without any graduated dials, by means of which the day could be divided into a number of equal parts. The length of the shadow determined the time for certain regular daily duties, as a shadow six feet long might indicate the time for bathing, and one twelve feet long that for supper.

As civilization advanced and the needs of the people required more accurate measures of time, the sun-dial was developed. We have already mentioned the sun-dial of Berosus, about 350 B. C., by means of which each day from sunrise to sunset was divided into twelve equal parts, that is provided the sun was visible all day long.

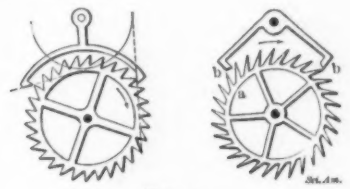


FIG. 5.

ANCHOR OR RECOIL ESCAPEMENT. DEAD-BEAT ESCAPEMENT.

As the sun-dial could not be used indoors or on cloudy days, as soon as the Grecian life became complex enough to need a timepiece under such circumstances, this demand was met by the clepsydra. The time of its introduction is not definitely known, but the familiar references of Aristophanes show its use to have been common about 430 B. C., while no mention is made of it by Herodotus, whose history ends fifty years earlier.

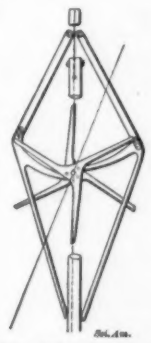


FIG. 6.—DENISON GRAVITY ESCAPEMENT.

A passage in Aristotle gives some idea of the early form of the clepsydra; it was a spherical bottle with a minute opening at the bottom and a short neck at the top into which the water was poured, and by closing which the flow of the water could be stopped. This form of clepsydra became a necessary adjunct of all courts of justice, and the number of

* Paper read before the American Association for the Advancement of Science.

gallons of water that a lawyer was allowed for his speech gave some indication of the importance of the trial. In fact, the word ὑδωρ became a synonym for time. We find Demosthenes charging his opponent with talking "in my water"; and on another occasion he shows the value he attached to the time allotted him by turning to the officer, when interrupted, with a peremptory "You there! stop the water!" reminding one of the "take out time" of our modern football contests.

The first timepiece of the Romans seems to have been the watchman who from the Senate House called forth noon as soon as he caught sight of the sun between the Rostra and the Graeco-Statis. From the same point he watched the declining sun and proclaimed its disappearance. This custom was probably instituted toward the close of the fifth century B. C. According to Pliny, the first sun-dial was set up in Rome about 290 B. C. About thirty years later Consul Valerius Mercala erected at Rome a sun-dial which was captured at Catania in Sicily. This instrument was not a mere gnomon such as was introduced three centuries earlier into Greece, but was the result of Grecian science and genius, constructed for a particular latitude, that of Catania, 5 deg. south of Rome. For a hundred years this sun-dial supplied the needs of the Romans for a timepiece, although it was constantly in error. Finally, in 164 B. C., Marcius Phillippus set up near the dial of Catania one constructed for the latitude of Rome, and Rome then possessed her first accurate timepiece; and during the time of Plautus the use of sun-dials became common.

As in Greece so in Rome, the clepsydra followed in the wake of the sun-dial, and as in the case of the sun-dial, Grecian science and genius had by this time produced a much more perfect instrument than that first used by the Greeks.

In describing the sun-dial of Berosus, I stated that by it the day was divided from sunrise to sunset into twelve parts varying in lengths from day to day called temporary hours. If now the clepsydra and the sun-dial were to read alike, it was necessary that the hours recorded by the clepsydra should also change from day to day. Various devices were adopted to accomplish this. Further, as the clepsydra could be used throughout the entire day and night, it was necessary to have it record hours of a different length at night from what it did in the day, as each night, i. e., from sunset to sunrise, was divided into twelve hours as well as each day.

Fig. 1 represents an early form of the clepsydra. It consists of an inverted cone *A*, with a small aperture at its vertex. The water is supplied through the pipe *H*, and is prevented from rising above a fixed level in *A* by the waste pipe *I*, which carries off the superfluous water. Thus there will be a uniform flow of water from the vertex of the cone into the cylindrical vessel, and the cork *F* will rise uniformly, communicating its motion through the rod *E* to the hand *G*, which indicates the hours on the dial. In order to produce a change in the rate of flow of the water from the conical vessel, as is necessary in having the hand indicate hours of different length from day to day, a solid cone *B*, similar to *A*, was plunged into the hollow one, and its position for any given day or night was indicated by the coincidence of a particular one of the adjusting marks on the stem *D* with the top cross-piece of the frame *C*.

A later form of clepsydra, attributed to Ctesibius, who lived during the latter part of the third century B. C., is shown in Fig. 2. *A* is the end of a tube over which an image stands, which is connected with a full reservoir, and from the eyes of which, considered as invariable apertures, the water continually flows or drops in a regulated manner into it; this tube conveys the water into the top of the cylindrical vessel *B C D F*, which gradually fills, the cork *D* with its attached pillar *C* rising at the same time. On the top of this pillar is an image holding an index, which points to the divisions on the large column above. Now when the water rises in the cylindrical vessel it also rises in the small tube, *F B*, which constitutes one leg of a syphon; consequently, when the small tube fills and the index has mounted to the top of the large column, the water flows over the bent part *B* of the syphon, and the vessel is emptied into one of the six troughs of the waterwheel *K*, which is thus turned one-sixth of a revolution, and the column, by means of the gearing shown in the figure, 1/365 of a revolution, during which time the image falls with its index to the bottom of the column, to be ready for the next day. There are ruled around the large column twenty-five lines properly sloped with respect to each other, so that the index may indicate the hour on any day of the year.

For the next fifteen centuries or more after the introduction of this clepsydra of Ctesibius, sun-dials and clepsydras were the timekeepers of mankind. These were then gradually supplanted by weight clocks.

I am not able to give the date of the manufacture of the first clock composed of an assemblage of wheels actuated by a suspended gravitating body and controlled by a regulator of some determined shape and dimensions, i. e., a regulated machine for measuring time without the assistance of water.

There may be seen at the South Kensington Museum an old clock movement, now controlled by a pendulum, which was removed about seventy years ago from a clock in Wells Cathedral, which is said to have been built by Peter Lightfoot about 1335 for the church at Glastonbury Abbey, from which it was removed to Wells Cathedral in the reign of Henry VIII., where, I believe, the dial and its accessories may now be seen. In addition to indicating the time, this clock was intended to indicate the age of the moon and to show its phase. Also it caused a man to strike the quarter hours with his feet on two little bells, and the hours on another bell before him with a battle-ax that is in his hand. It also set in motion four equestrian knights equipped for a tournament. If the date given for the clock is correct, the figures operated in connection with it are hardly the original ones. One of the knights is painted in the civil costume of the seventeenth century.

About 1360 there was erected in the tower of the palace of Charles V. of France, a clock constructed by Henry de Vick, of Würtemberg. This clock was made for the simple purpose of telling the time of day, and was not expected to perform the numerous feats that were so frequently required of clocks in earlier days, and may be taken as a type of the earliest clock movements.

From Fig. 3, giving both a front and a side view, the operation of the clock may be clearly understood. The motion of the falling weight *A* is transmitted by means of the wheels *G*, *e*, *H*, and *g* to the wheel *I*; this last wheel, by giving the pallets or short levers, *h*, *i*, each a push alternately by two teeth, at opposite sides of its circumference, and moving in opposite directions, one forward and the other backward, gives a vibratory motion to the vertical arbor, *K*; and as the regulator or balance was fixed on this arbor, it was thus made to vibrate backward and forward at every push of the escapement wheel upon the pallets, the period of the vibration being regulated by the position of the small weights *m*, *m* on its arms. Thus the whole duration of a vibration was the measure of time, and the wheels and pinions were employed first to transmit the maintaining power to the balance, and secondly to number the vibrations and indicate them in visible form by a hand, *O*, on a dial plate. Fig. 4 gives a view of the escapement wheel looking from above. The pallets were placed at about 90 deg. from each other on the arbor or verge of the balance, so that when one of them was parting with its tooth of the escapement wheel, the other was in a situation to receive the opposite one immediately, but the motion of the verge will not be at once reversed. The escape wheel will recoil until the impetus of the balance is exhausted.

The substitution of the main spring for a large heavy body as a first mover constituted a second era in modern horology, from which we may date the origin of the fusee, or mechanism for equalizing the variable power of a coiled spring.

While the date at which the first portable clock was made may not be definitely stated, it was certainly as early as 1525, as the Society of Antiquaries in England has in its possession one made in that year by Jacob Zech at Prague, the inventor of the fusee. Its construction differs materially from that of De Vick's clock only in that it has a spiral spring with a fusee instead of the driving weight.

Such was the state of clockwork when Galileo, the celebrated philosopher and mathematician, while watching the vibrations of the great bronze lamp swinging from the roof of the cathedral of Pisa in 1583, observed that whatever the range of its oscillations, they were invariably executed in equal times. Because of this isochronal property of a vibrating suspended body, the pendulum was introduced as the regulator of clockwork, thus inaugurating the third era in the development of the modern clock.

The honor of being the first to apply a pendulum as a regulator of clockwork is claimed for several clockmakers.

The earliest of these is, I believe, Richard Harris, who is said to have made a pendulum clock for St. Paul's Church, Covent Garden, in 1641. Vincent Galileo claims to have applied his father's discovery to the construction of a pendulum clock in 1649, but does not seem to have made the fact public until after Huyghens in 1657 presented to the States of Holland a clock controlled by a pendulum, claiming for himself the invention of this form of control. Certain it is that Huyghens gave much study to the mathematical theory of the pendulum, and proved that in order that pendulum vibrations of different lengths should be strictly isochronal, the pendulum should vibrate between cycloidal cheeks. Such an arrangement he introduced into his clock of 1657, which also contained the famous Huyghens loop in connection with the winding apparatus.

With the verge escapement, Fig. 4, the one in use when the pendulum was applied to clockwork, and which required a long arc of vibration for the escapement of the escapement wheel, the deviation of the circular arc described by an ordinary pendulum from the theoretical cycloidal arc was of necessity taken into account. With the introduction of the anchor or recoil escapement, Fig. 5, invented by Dr. Hooke about 1675, the long swing of the pendulum was obviated, and the cycloidal cheeks were found to be more detrimental than advantageous.

The expansion of metals by heat has been known ever since the middle of the seventeenth century, and early in the eighteenth George Graham set himself the task of making a clock pendulum such that the distance between the center of oscillation and the center of suspension would be independent of the temperature. I quote from his paper "A Contrivance to Avoid Irregularities in a Clock's Motion by the Action of Heat and Cold upon the Pendulum," communicated to the Royal Society in 1726:

"Whereas several who have been curious in measuring time have taken notice that the vibrations of a pendulum are slower in summer than in winter, and have very justly supposed this alteration has proceeded from a change of length in the pendulum itself, by the influence of heat and cold upon it, in the different seasons of the year; with a view, therefore, of correcting, in some degree, this defect of the pendulum, I made several trials, about the year 1715, to discover whether there was any considerable difference of expansion between brass, steel, iron, copper, silver, etc., when exposed to the same degree of heat as nearly as I could determine, conceiving it would not be very difficult, by making use of two sorts of metals, differing considerably in their degrees of expansion and contraction, to remedy, in great measure, the irregularities to which common pendulums are subject. But although it is easily discoverable that all these metals suffer a sensible alteration of their dimensions by heat and cold, yet I found their differences in quantity from one another was so small, as gave me no hopes of succeeding this way, and made me leave off prosecuting this affair any further at that time. In the beginning of December, 1721, having occasion for an exact level, besides other materials I made trial of, quicksilver was one; which, although I found it was by no means proper for a level, yet the extraordinary degree of expansion that I observed in it when placed near the fire, beyond what I had conceived to be in so dense a fluid, immediately suggested to me the use that might be made of it by applying it to a pendulum. In a few days after I made the experiment, but with much too long a column of quicksilver, the clock going slower with an increase of cold, contrary to the common pendulum; however, it was a great confirmation of the advantage to be expected from it, since it was easy to shorten the column in any degree required."

As his first jar was too long, so his second was too short, but by June 9, 1722, he was ready to test the running of his mercury pendulum clock with one regulated by an uncompensated pendulum. He says: "For the first year I wrote down every day the difference between the two clocks, with the height of the thermometer, not omitting the transits of the stars as often as it was clear. The result of all the observations was this, that the irregularity of the clock with the quicksilver pendulum, compared with the transits of the stars, exceeded not when greatest a sixth part of that of the other clock with the common pendulum; but for the greatest part of the year, not above an eighth or ninth part, and even this quantity would have been lessened had the pillar of mercury been a little shorter, for it differed a little the contrary way from the other clock, going faster with heat, and slower with cold; but I made no alteration in length to avoid an interruption of the observations."

A few years afterward John Harrison brought out his gridiron pendulum composed of four brass and five steel rods, so constructed that the expansion of the steel rods tended to lower the pendulum bob while the expansion of the brass ones tended to raise it.

Another form of compensated pendulum that has found favor is the zinc tube pendulum, in which the zinc tube surrounds a rod of steel and is itself surrounded by a tube of steel. Here the zinc tube fulfills the purpose of the brass rods in the gridiron pendulum. At present at least one firm of clock manufacturers is using invar or nickel steel for its pendulum rods.

Attempts have also been made to compensate a pendulum to avoid changes in the rate due to changes of the barometer. At Greenwich this is accomplished by attaching a magnet to the end of the pendulum, and causing a second magnet supported below the pendulum to approach or recede from the pendulum with changes of the barometer.

This second magnet increases the acceleration due to gravity to a greater or less degree as it approaches or recedes from the pendulum.

The most satisfactory way, however, of freeing a clock rate from variations due to changes of temperature and pressure is to inclose the clock in an air-tight glass case kept in a room of constant temperature. A number of observatories now keep their standard clocks under such conditions.

Another improvement in the manufacture of clocks was accomplished by Graham in the introduction of the deadbeat escapement.

In Fig. 5 are shown both the anchor or recoil escapement and the dead-beat escapement. In the first, shown on the left, the pendulum moving to the left has just escaped a tooth at the left-hand pallet, and allowed a tooth to fall on the right-hand one. The pendulum, however, still continues its swing to the left, and in consequence the pallet pushes the wheel back, thus causing the recoil that gives the name to the escapement. It is only after the pendulum comes to rest and begins its excursion the other way that it gets any assistance from the wheel, and the difference between the forward motion of the wheel and its recoil forms the impulse. In the right-hand figure, the pendulum moving to the right has just escaped a tooth from the right-hand pallet, while another has fallen upon the left-hand one. As the pendulum continues its motion toward the right, the left-hand pallet slides over the point of the tooth, but there is no recoil, as the "dead" face, as it is called, is the arc of a circle whose center is the point about which the anchor turns. As the pendulum returns toward the left, the tooth traverses the "dead" face in the opposite direction, and immediately upon leaving this face it passes to the "impulse" face, and while passing along this face gives the impulse to the pendulum.

The great advantage of the dead-beat escapement over the anchor or recoil type is that, although a slight increase of force on the escapement wheel increases the arc of the pendulum, it does not sensibly increase the time, while the time does sensibly increase with the recoil escapement.

At about this time also Mudge introduced the gravity escapement. With all the previous escapements the impulse was given to the pendulum by the driving weight acting through the train, so that any irregularities in the train would cause a variation in the impulse. With the gravity escapement a weight is raised by the train, and the falling of this weight gives the impulse to the pendulum. We thus have a uniform impulse at each oscillation, due to the falling of a weight through a fixed distance. Simple and elegant as is this theory, the application of it gave a great deal of trouble, and all gravity escapements were regarded with suspicion, as having a tendency to trip, until Mr. Denison designed the double three-leg one for the great clock at the houses of Parliament about fifty years ago. Incidentally it might be mentioned that this Westminster clock has turned out to be the finest timekeeper of any public clock in the world. The original specifications required that the clock should be guaranteed to perform within a margin of a minute a week, which caused the leading clockmakers of England to decline to bid for the work. However, under Mr. Denison's supervision the clock was built by Mr. Dent, and from reports of the Astronomer Royal, who receives at Greenwich two signals a day from this clock sent automatically, its error is rarely over a second a week.

The Denison gravity escapement is shown in Fig. 6. This escapement consists of two gravity impulse pallets pivoted as nearly as possible in a line with the bending point of the pendulum spring and touching the pendulum near the bottom of the figure. The locking wheel is made up of two thin plates having three long teeth or "legs" each. These two plates are squared on the arbor a little distance apart, one on each side of the pallets. Between them are three pins which lift the pallets. In the figure, one of the front legs is resting on a block screwed to the front of the right-hand pallet. There is a similar block screwed to the back of the left-hand pallet for the legs of the back plate, which is shaded in the figure, to lock upon. Projecting inward from each of the pallets is an arm. The tip of the one on the right-hand pallet is just in contact with one of the pins, which has lifted the pallet to the position shown. The pendulum is traveling in the direction indicated by the arrow, and the left-hand pallet has just given impulse. The pendulum rod in its swing will push the right-hand pallet far enough for the leg of the front locking plate, which is now resting on the block, to escape. Directly it escapes, the left-hand pallet is lifted free of the pendulum rod by the lowest of the three pins. After the locking wheel has passed through 60 deg., a leg of the back locking plate is caught by the locking block on the left-hand pallet. As the three-leaved pinion always lifts the pallets the same distance, the pallets in returning give a constant impulse to the pendulum.

About fifteen or twenty years ago the Rieflers, clockmakers of Munich, introduced into their clocks an escapement in which the impulse is communicated to the pendulum through the suspension spring. The pendulum is supported by a rocking frame, to which is attached the anchor carrying the pallets, which are acted upon by the escapement wheel. Just after the pendulum has passed through its vertical position, the escapement wheel, when released, gives to the supporting frame of the pendulum suspension spring a slight tilt in the opposite direction from that in which the pendulum is moving, thus increasing the tension of the spring due to the swing of the pendulum to one side.

In the next few minutes I wish to consider the accuracy with which our astronomical clocks perform their function.

The earliest star catalogue of precision is that of Bradley, and the observations upon which it is based were made about a third of a century after the introduction of the compensated pendulum. In discussing the performance of his clock, I have used the adopted rates as given by Auwers in his re-reduction of Bradley. The monthly means of the rates from July, 1758, to July, 1759, were taken, and the difference of each rate from its monthly mean. Then the mean of these differences without regard to sign was taken for each month.

The rates of two other clocks of the Greenwich Observatory were likewise discussed, the standard clock for the year 1850 and that for 1900, the adopted daily rates as published in the annual volumes being used. The first of these was kept in the observing room, and thereby subjected to large variations of temperature, while the second, made in 1871 by E. Dent & Co., was fixed to the north wall of the magnetic basement, as in this apartment the temperature is kept nearly uniform. The pendulum of this latter clock is provided with barometric as well as thermometric compensation.

VARIATION OF DAILY RATE OF THREE GREENWICH SIDEREAL CLOCKS.

Bradley's Clock.			Sidereal Stand, "Hardy."			Sidereal Stand, "Dent."		
Date.	Daily Rate	Mean Residual.	Date.	Daily Rate	Mean Residual.	Date.	Daily Rat.	Mean Residual.
1758	s.	s.	1850	s.	s.	1900	s	s.
July	−0.086	0.060	Jan.	+0.606	0.269	Jan.	+0.280	0.035
Aug.	−0.012	0.079	Feb.	+0.857	0.162	Feb.	+0.196	0.041
Sept.	−0.012	0.077	March	+0.930	0.117	March	+0.170	0.038
Oct.	−0.130	0.166	April.	+1.154	0.257	April	+0.134	0.027
Nov.	−0.094	0.127	May.	+1.607	0.105	May	+0.078	0.028
Dec.	−0.190	0.096	June	+1.372	0.117	June	+0.022	0.045
1759								
Jan.	−0.264	0.106	July.	+1.058	0.202	July	−0.096	0.039
Feb.	−0.343	0.072	Aug.	+0.821	0.104	Aug.	−0.245	0.053
March.	−0.449	0.108	Sept.	+1.007	0.087	Sept.	−0.381	0.056
April	−0.310	0.125	Oct.	+1.049	0.120	Oct.	−0.549	0.048
May	−0.322	0.127	Nov.	+1.232	0.063	Nov.	−0.522	0.161
June	−0.439	0.086	Dec.	+1.389	0.187	Dec.	−0.259	0.036
Mean		0.102	Mean		0.149	Mean		0.051

I sought to make a similar comparison for the clocks of the other large observatories, but soon found that the information concerning the performance of the various clocks was given in such a form that it was in almost every case either impossible or extremely laborious to secure the desired result. However, there are two well-known clocks which should be mentioned in this connection, and in conclusion I will give some hitherto unpublished data concerning the clock with which I have been working during the past three years.

Probably no clock has had its rate more thoroughly discussed than Hohwü No. 17, the standard clock of the observatory at Leiden.

It was set up in the transit room in 1861, and in December, 1898, was removed to the large hall of the observatory, where, inclosed in two wooden cases, it was placed in a niche cut in the pier of the 10-inch refractor. To further guard against sudden changes of temperature, the niche is closed by a glass door. At the meeting of the Royal Academy of Sciences at Amsterdam, held September 27, 1902, Dr. E. F. van de Sande Bakhuyzen submitted the following formula as the best representation of the daily rate of the clock:

$$\text{Daily rate} =$$
$$-0s.0173 + 0s.0157(h - 760mm.) - 0s.0253(t - 10°)$$
$$+ 0s.00074(t - 10°)^2 + 0s.0465 \cos 2\pi \frac{T - \text{May } 3}{365}$$

and gave the result of a comparison of the observed daily rates 1899-1902, the average interval of time for each rate being six days, with those computed by means of the above formula. I find during the year 1900 the mean of these differences is

0s.028

and the largest difference is 0s.071.

About 1867 F. Tiede installed at the Berlin Observatory a weight-driven clock inclosed in an air-tight case. The original escapement was replaced in 1876 by a gravity escapement, and the clock continued to give satisfaction certainly up until 1902, when it was dismounted for cleaning. The only published rates that I have been able to secure are those during twelve weeks in 1877-78. During this period the average deviation of the observed daily rates, the average interval for each rate being six days, from the mean daily rate for the entire period is

0s.030.

In connection with the publication of these rates* the statement is made that for weeks at a time this mean deviation will not exceed 0s.02.

In 1903 there was installed at the Naval Observatory one of Riefler's clocks, No. 70, with a nickel steel pendulum, the impulse being communicated to the pendulum through the suspension spring. This clock was inclosed in an air-tight glass case, and was mounted in a vault where the temperature was artificially controlled. The definitive rates have been determined from September, 1903, to May, 1904, but unfortunately during this entire period we were unable to prevent the glass case leaking, and there was a variation of temperature in the vault of about 5 deg. C. However, from the first of February to the middle of May the pressure was kept nearly constant by reducing it each day by means of an air pump by from 1 to 2 millimeters. During this period the following results were obtained.

DAILY RATE OF RIEFLER SIDEREAL CLOCK NO 70.

Date.	Daily Rate.	Mean Barometer.	Mean Temperature.	Computed Rate.	O.-C.
1904	s.	Mm.	Deg. C.	s.	s.
February 8-11....	+0.019	631.0	28.3	+0.009	+0.010
February 11-15....	−0.014	631.5	28.5	−0.006	−0.008
February 15-20....	+0.005	631 5	28.3	−0.002	+0.007
March 1- 4....	−0.026	631.0	28.2	−0.012	−0.014
March 4- 9 ..	−0.010	631.0	28.2	−0.016	+0.006
March 9-16 ...	−0.022	631.5	28.1	−0.018	−0.004
March 16-18.	−0.043	631.0	28.1	−0.022	−0.021
March 18-22....	−0.022	631.0	28.0	−0.021	−0.001
March 22-25.	−0.029	631.0	28.0	−0.024	−0.005
March 25-28....	+0.002	631.0	27 7	−0.014	+0.016
March 28-31..	−0.007	631.0	27.7	−0.018	+0.011
April 3- 5.	−0.017	631.0	27.4	−0.009	−0.026
April 5-13....	−0.002	631.0	26.9	−0.014	+0.012
April 13-16.	−0.026	631.0	26 5	−0.021	−0.005
April 16-19...	−0.034	631.0	26.3	−0.027	−0.007
April 19-22..	−0.002	631.0	26.4	−0.020	+0.018
April 22-31.	−0.029	631.0	25.0	−0.077	−0.048
May 1- 4....	−0.113	631.5	24.3	−0.103	−0.010
May 4- 7..	−0.082	631.0	24.1	−0.109	−0.027
May 7-12...	−0.161	631.0	24.0	−0.109	−0.052
Mean.....					±0.015

The formula from which the computed rate is obtained, Daily rate $= +0s.0161 - 0s.00103$ (T-Mar. 29.0) $- 0s.0456$ (t-27°.0) is the result of a least square solution of the twenty observed rates.

Collecting together the results given above we have:

Mean Deviation of Daily Clock Rate.

Clock.	Date.	Mean Deviation.
Bradley	1759	0.102
Greenwich Observatory ..	1850	0.149
Greenwich Observatory ..	1900	0.051
Berlin Observatory	1877	0.02 —0.03
Leiden Observatory	1900	0.028
U. S. Naval Observatory..	1904	0.015

In considering this table, I hope the particular method by which each of the numbers given was obtained will be remembered. The reason for using different methods has already been given. If the rates of the first three clocks had been treated in a manner similar to that used in the last three cases, the numbers given might have been slightly smaller; and if the period under consideration with the Berlin and Washington clocks had been longer, the two corresponding residuals might have been slightly larger.

Peat products are now manufactured with great success in an extensive plant erected not long since at Redkino, Russia, in a district where the peat can be easily obtained. The process consists in carbonizing the peat in a set of special furnaces. At present there are eight large furnaces of this kind installed in the plant, and they are worked continuously. The capacity of each furnace is from 25 to 30 tons of product per day. As to the kind of product which the furnaces deliver, it is divided into two varieties. It should be mentioned that the furnaces work in all cases by the distillation of the peat. When the distillation is complete, the product is a variety of coke which is very hard and resistant, and is very good for use as fuel in blast furnaces. It is said to have about the same value as coal. Another method is to carry on the distillation at a lower heat than before. The resulting product gives a half-formed coke which is softer and burns much more easily. It burns with a flame, like coal, but gives less heat. Both these products are of advantage in the iron industry, seeing that they contain but a small amount of sulphur. A number of by-products are secured from the distillation of the peat by the present process. Among these may be mentioned tar and ammoniacal products as well as gases which come off, and the latter can be burned in the furnaces, making the process a very economical one.

* A. N. No. 2184.

SCIENCE NOTES.

The reading habit is essentially modern and may be said to date from the rise of periodicals, comparatively few of which are more than half a century old. The invention of spectacles and that of printing were very nearly coeval. Until that date literary instruction was largely a matter of dictation, repetition and memorizing, as is still the case in many parts of the world. Among the ancient Greeks and Romans the memory was trained to a far greater extent than with us. In the literature of the former there is constantly evident a sort of distrust of the written page. It could not reflect the vivifying power of the living voice. It seems to have been a common thing for Greek youths to learn Homer by heart, huge as the task would be to us. Knowledge was to be elicited by discussion, by the dialectic method, by question and answer. Intellectual training was almost exclusively rhetorical. Taking into consideration, therefore, the fact that eyes were not needed for the manufacture and use of instruments of precision and that the printed page did not exist, we can easily understand that spectacles were not greatly missed.

The specimens recently brought to Paris from the region of Lake Tchad and its affluent the Chari River by the Foureau-Lami expedition, Dr. Decorse and others, throw some light upon the character of the fauna of this region. While most of the specimens show that the Lake Tchad basin does not differ materially from the other great basins of the continent, such as the Nile, the Senegal, Congo and others, some new specimens are found, among which is a curious flying fish of small size, measuring but two inches in length. It has a very brilliant color, and is possessed of a pair of pectoral fins which are very much developed and resemble wings, so that the fish can spring out of the water and skim upon the surface for a distance of 12 or 15 feet, and sometimes even for 60 feet. It is found in the Victoria River, near Kameroun. Among the rare forms of the Chari River is the *Protopterus annectens*, which has also been found in the Senegal and even in the Zambezi. They possess lungs as well as gills and their habits are curious, seeing that they live in marshes which dry up during a great part of the year. In this case they bury themselves in the mud and roll themselves in a kind of cocoon lined with a gelatinous compound, and breathe with their lungs. The natives hunt for them in this state, and use them as food. They keep the pieces of earth containing them and thus store them for use. In the Tchad region are found the Hydrocyons or river dogs, which have powerful jaws armed with enormous teeth with sharp cutting edges. They will easily cut the copper wire which is used to hold the fish hooks, and Dr. Decorse states that they sometimes cut cords as thick as the little finger and carry off iron hooks three inches long. The variety which is found in the Chari River is the *Hydrocyon Forskali*, and it is met with also in the Nile and the Senegal.

A paper presented to the French Académie des Sciences by Lieut. Tsoucalas, of the Greek navy, and by Lieut. Vlahavas, of the Greek artillery, has been published in the Comptes Rendus. In this paper, which supplies a comparative study of aeroplanes and bladed air propellers (hélicoptères) the authors make a comparison between the two modes of attacking the problem relating to the movement of bodies heavier than air. This investigation is based absolutely upon mathematical analysis of the facts, and is conducted in such a way that the results obtained are indisputable. After having calculated the most favorable inclination for the surfaces of the aeroplanes, they demonstrate unmistakably that the aeroplane is entirely condemned, since it presents no advantage in any way as compared with the screw. Indeed, in the most favorable position for the aeroplane, but one not practically possible, the screw will give with one-third of the work needed for the aeroplane the same amount of sustentation. When put to practical test the advantage of the screw becomes even more marked. Thus, as the result of the most recent experiments, it is found that with only six per cent of the work put into the aeroplane the screw will give the same amount of sustentation and the same effect of translation. Moreover, in the case of the screw there is no need of planes of support, which entail useless weight and interfere with the stability. Finally the authors, making use in all cases of analysis, prove that the theory relied upon hitherto by experimenters with aeroplanes must be rejected, since in effect it conducts to perpetual motion. They thus claim to demolish a theory which until now has been accepted as axiomatic, and having shown this to be so there remains no advantage whatever in the use of the aeroplane. All future attempts should henceforth, therefore, be made with the screw or with other systems based on direct action. The authors say the introduction of aeroplanes with their imagined advantages has given a wrong direction to the efforts of experimenters who desired to attack the problem of the movements of bodies heavier than air, and these have been encouraged by the apparent success of certain recent but fallacious tests. In fact, they add, a careful analysis of these experiments leads to the conclusion that these results have not been in the nature of flight, but were due to a leap in the air.—The Times (London) Engineering Supplement.

ENGINEERING NOTES.

Evidence exists that a work similar to the famous Simplon tunnel, but on a smaller scale, was executed some twenty-four centuries ago. Owing to the bad state of the water supply of Jerusalem, says the Iron Age, the King ordered a reservoir to be made at the gates of the city, to which water was to be brought from various springs. The Shiloh tunnel, by means of which water was brought down from a source to the east of Jerusalem and poured into the pool of Siloam, was 1,080 feet long, and is in a straight line. It has been learned that work was commenced at both ends of the tunnel, and the direction altered a number of times. The floor of the tunnel is finished with great care. The width varies from 1.9 to 3 feet and the height from 3 to 9 feet. There is much speculation as to how these engineers gaged their direction so well as to be able to recognize and correct errors in alinement, as was certainly done.

The Public Service Commissions which will exercise supervision of the railway and lighting companies in the State of New York are made up of men of high standing. Some of them have taken an active interest in party politics, but none are "politicians." Most of them are lawyers, but business, manufacturing, and engineering are also represented. Whether these men are capable of team work cannot be foretold; if they are not then the famous plan of controlling public utilities devised by Gov. Hughes will come a tremendous cropper, for the commissions replaced by the two new ones did fair work. The new commissions undertake their duties with a great handicap, from the fact that the same kind of control in different parts of the State is vested in two independent bodies, each with powers of making rules and regulations to govern the companies under its jurisdiction. If the New York Central & Hudson River Railroad Company has to obey one set of regulations until it comes down to the New York city line, and then must obey a different set of regulations, is there any likelihood that this complication cannot be utilized by the company to nullify effectively any regulations it does not like? While the appointment of two commissions with equal powers, one for the city and the other for the State outside the city, may have been a good political move to secure the adoption of the general principle of centralized State control of public utilities, it seems a pretty severe tax on human nature to expect the two commissions to agree, even on the most important features of their work. It is therefore reasonable to expect that before long the two bodies will be consolidated, and the work of the consolidated commission will be arranged so that everywhere in the State the supervision of public utilities contemplated by the spirit of the legislation will be uniform and effective. —Engineering Record.

Experiments made on the Pennsylvania Lines West with reinforced concrete for telegraph poles, were described at the Association of Railway Telegraph Superintendents, in session at Atlantic City recently, by G. A. Cellar, superintendent of telegraph of the Pennsylvania Lines West, who said in part: "J. B. McKim, superintendent of the Western division of the Pennsylvania Lines West of Pittsburg, made and set up last year in the line along the Pittsburg, Fort Wayne & Chicago near Maples, Ind., 53 reinforced concrete poles of graceful proportions. These poles are small in section and approach the minimum in weight. They have thus far given entire satisfaction and show no evidence of decay. In the working out of the plans for the requisite strength with the minimum of weight, two hollow poles were made. One of the patterns was square in section, with the corners chambered off; the other, octagonal in section, and the hollow space extending from the base for about two-thirds of the length of the pole, the upper third being solid, and the walls of the lower two-thirds being from 1¾ inches to 3 inches thick. These poles weighed approximately 3,500 pounds. The test was made in connection with two carefully selected cedar poles of the same length (30 feet), and all were set in concrete, the base being 3 feet by 3 feet by 5 feet deep. Just within the outer surface, the walls of the concrete poles were reinforced with iron rods, which consisted of four ¾-inch bars, each 24 feet long, and four ⅝-inch round bars of the same length. The concrete poles were set to a depth of five feet in concrete with two white cedar poles of practically the same dimensions, and, after standing long enough to permit the cement to become solid, they were tested in turn in the following manner: An iron clevis was placed around the pole to be tested 10 inches from the top, to which a wire rope was attached, leading over a pulley placed at the same height and at an equal distance from the pole so as to form a right angle, and fastened to a differential pulley block, which was attached to a laboratory weighing machine. After the cement poles had been broken, the reinforcement so held them that it required almost the breaking pressure to further deflect them from their slightly inclined position. The wooden poles, under strain, presented the form of an arch before breaking, and when they gave way were fractured completely; but these features were lacking in the cement poles, which were very firm and did not give until they began to crush at the ground line.—Railway and Engineering Review.

TRADE NOTES AND FORMULÆ.

Cardboard Varnish.—Shellac dissolved in sufficient quantity and an equal quantity to the shellac in weight, of linseed oil, added. To each 1,000 parts of the mixture add 10 parts of chloride of zinc. The paper should be dried before use and rubbed down with pumice stone.

Carmine Solution for Microscopical Purposes (according to Cucatti).—30 parts of the finest carmine and 100 parts of crystallized carbonate of soda are rubbed down, and with 750 parts of distilled water brought to a boil in a porcelain dish. After the solution is effected, add to the cooled fluid carefully: 50 parts of alcohol, 50 parts of acetic acid (20 per cent), 20 parts of chloral hydrate, and as much distilled water as will make the total quantity of fluid 1,000 parts.

Curry Powder is an East Indian spice mixture extensively used in England, of sharp, piquant flavor, made from coriander, cardamom, turmeric, white and red pepper, ginger, salt, mustard, and various other spices and used for the flavoring of many meat dishes as well as sauces and soups. Recipe: 16 parts of turmeric, 6 parts of white pepper, 3 parts of Jamaica pepper, 3 parts of black mustard, freed from oil, 3 parts caraway seeds, 1 part coriander, 1 part Cayenne pepper, ground as fine as possible and mixed.

To Color Bristles (Hairs) Black.—In 1,000 parts of hot water dissolve 30 parts of tartaric acid, then gradually add 30 parts of soda crystals, then 50 parts of wool black and 2.5 parts of naphthol yellow. Into the hot color bath place the thoroughly cleansed (especially freed from fat) hairs, allow them to remain there about an hour, press out any remaining coloring solution and dry them. After drying, wash them out in water and treat them with a cold solution of 3 parts of tragacanth and 20 parts of glycerine, in 1,000 parts of water, after which they must again be dried.

Cerophanies (Translucent Pictures Resembling Porcelain).—Pour wax, colored as desired, into flat plaster molds. On a glass plate pour a layer of white or colored wax, about 15 millimeters (3/5 inch) thick. Make a rim around the plate of stiff paper and pour the wax in. In this wax layer the picture is engraved, at dark spots, more wax, surrounded by a wood or metal frame and poured over with good and well stirred alabaster-plaster. Remove the gypsum cast after hardening, pour into it white (colored with white lead or zinc-white) or particolored wax, then remove it.

To Dye Celluloid Objects Different Colors.—*Black:* The object is first dipped in weak lye, then in a weak solution of nitrate of silver and allowed to dry exposed to the light. *Blue:* For this we use an indigo solution, almost neutralized with potash; also Berlin blue solution; also on the one hand chloride of iron solution and on the other ferrocyanide of potassium solution. *Green:* Place the object in a solution of 2 parts of verdigris and 1 part chloride of ammonia. *Yellow:* Immerse the object first in a solution of nitrate of lead and then in a solution of yellow chromate of potash. *Brown:* Use a solution of permanganate of potash made alkaline with soda. *Red:* Immerse the object first in water weakly acidulated with nitric acid, then in ammoniacal cochineal or carmine solution. *Purple:* Immerse the object in dilute solution of chloride of gold and then expose to strong light.

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